

Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



MAY 1955

No. 5

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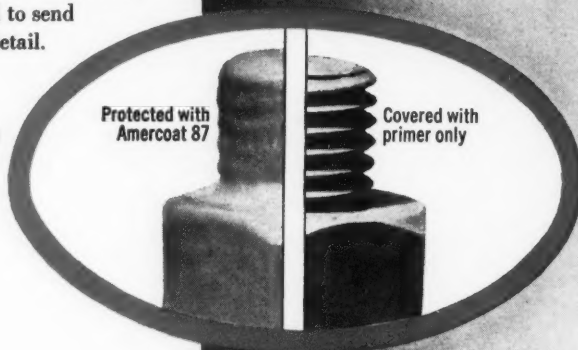
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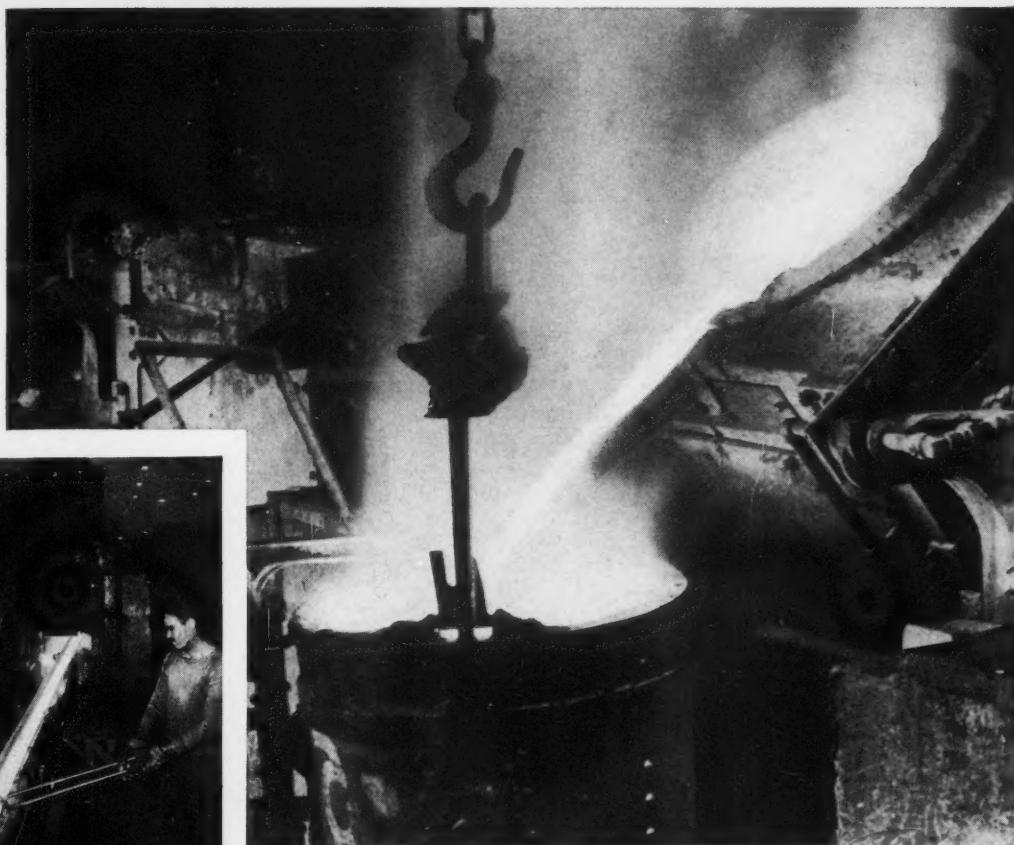


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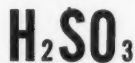
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Corrosion



THIS MONTH'S COVER—The upper diagonal half of this illustration shows a heat treating furnace used to treat stainless steels to reduce intergranular corrosion (such as that shown in the lower half) of a Type 316 cast stainless steel head removed from acetic acid service. Heat treatment may reduce the tendency of corrosives to attack grain boundaries.



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CONTENTS

	Page
Directory of NACE Technical Committees.....	4-6
Officers and Directors, National Association of Corrosion Engineers.....	16

TECHNICAL SECTION

Topic of the Month—"Hot Fence" Is Unexpected Ground Bed Hazard By Frank E. Stettler.....	17
A Practical Method for Cleaning and Descaling Cargo Tanks Contaminated With Black Oil Residue By J. F. Mills, F. E. Cook and H. S. Preiser.....	18
Advantages of Wood Lined Steel Pipe in Corrosive Services By E. H. Bronstein.....	23
Coating Pipelines in Place Internally With Plastics By J. C. Watts.....	28
Strong Earth Currents Complicate Surface Potential Measurements—A Technical Note By David Hendrickson.....	34
Laboratory Development of Corrosion Inhibitors By Loyd W. Jones and Jack P. Barrett.....	35
Material Selection for Condenser Tubes By Harold A. Todhunter.....	39
Economic Considerations in Pipe Line Corrosion Control By L. G. Sharpe.....	45
Discussions: W. H. Stewart, H. E. Waldrup, Page 51; L. F. Sherer, Page 52; N. K. Senatoroff, Page 53; Guy Corfield, R. D. Howell, Charles L. Woody, Page 55; Leonard C. Hill, N. P. Peifer, Page 56; John R. Ligon, Scott P. Ewing, Page 57; Replies by L. G. Sharpe: Pages 53, 54, 56, 57, 58.	
High Temperature Corrosion Data—A Compilation by Technical Unit Committee T-5B on High Temperature Corrosion. Publication 55-6.....	59
ERRATA: Minimizing Stress Corrosion Cracking of Cylinder Valves by M. Schussler; Proposed Methods for Cathodic Protection of Composite Structures by M. Unz.....	44

NACE REGIONAL AND SECTIONAL NEWS

	Page		Page
Northeast Region Meeting Opens May 9.....	65	Dehn Talks at Dallas.....	68
Topics Given for Washington U. Course.....	65	Pierce Discusses Masonry at Orange.....	68
Electrolysis Committee Discussed at Toronto.....	65	Permian Basin Section.....	68
Ulmer Discusses Boiler Water at Baltimore.....	66	Portland Cement Is Topic at Detroit.....	68
Southwestern Ohio Nominates New Officers.....	66	New Orleans-Baton Rouge Section New Officers.....	68
Industrial Painters Course at Corpus Christi.....	66	Carbon Anode Applications Reviewed.....	70
National, Regional Meetings and Short Courses.....	66	at Los Angeles Session.....	70
NACE Calendar.....	66	Stress Corrosion Discussed at San Francisco.....	70
Silicones Discussed at Corpus Christi.....	67	Portland Section Meeting.....	70
Houston Section Social Meeting Scheduled.....	67	Uhlig Talks at San Diego.....	70
Corrosion in Home Is Houston Topic.....	67		

TECHNICAL COMMITTEE NEWS

	Page		Page
Seven Committees to Meet in Houston in October.....	71	Task Group on Fundamentals.....	72
Skinner Is Vice-Chairman of T-5B.....	71	HF Corrosion Group Formed.....	72
41 Are Present for Coatings Research Session.....	71	Marine Coatings Use Recommendations Sought.....	72
Stray Current Electrolysis Report Discussed.....	71	13 Companies Report on Inhibitor Screening Test.....	74
Shrimp Is New Head of T-1A.....	71	Aims of Tanker Corrosion Committee Discussed.....	74
Scope of Prefabricated Plastic Film Committee T-5D on Plastic Materials of Construction.....	72	Report Being Prepared on Concentration Cells Revision of Masonry Report to Be Distributed.....	74
Plans Symposium for 1956.....	72	T-2C-1 Is Reorganized.....	74

GENERAL NEWS OF CORROSION INTEREST

	Page		Page
1956 Conference to Have International Flavor.....	70	India Plans 15-Inch Gas Line.....	77
Fundamentals to be Stressed at Gordon Conference.....	75	AWWA Convention to be Held at Chicago.....	78
Sub-Zero Hardening Feature of New Stainless Alloy.....	75	AWS Spring Meeting Set June 7-10.....	78
LaQue Reviews U. S. Corrosion Activities.....	75	LP Centrifugal Pump Standard Proposed.....	78
Armour Report Reveals Corrosion Work.....	76	FPVPC Appoints 10 to Corrosion Committee.....	80
		Book Reviews.....	82
		New Products.....	82

INDEX TO CORROSION ABSTRACTS.....	91
INDEX TO ADVERTISERS.....	128

Copyright 1955 by the National Association of Corrosion Engineers. Reproduction of the contents, either as a whole or in part, is forbidden unless specific permission has been obtained from the Editor of *CORROSION*. Articles presented represent the opinions of their authors, and not necessarily those of the Editors of *CORROSION*, nor the Officers or Members of the National Association of Corrosion Engineers. Manuscripts to be considered for publication should be forwarded, together with illustrations, to the Editor of *CORROSION*, 1061 M & M Building, Houston 2, Texas.

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T-6A Organic Coatings And Linings For Resistance To Chemical Corrosion

R. McFarland, Jr., Chairman, Hills-McCanna Co., 3025 N. W. Ave., Chicago 18, Illinois

C. G. Munger, Vice Chairman, Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.

J. J. Ondrejcin, Secretary, E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., Wilmington, Delaware

(Continued on Page 6)



CLEANING, COATING, WRAPPING & RECONDITIONING

HOT DOPE

Straight from the Kettle
on PIPE PROTECTION

By Boyd Mayes

Years ago I fell victim to a suit of clothes that was so cheap it seemed unbelievable. The suits looked okay in the window and the salesman really gave me a good pitch on how much money I was saving. Since I'm not allergic to saving a few dollars, I bought that suit. I wore it just a few times. It never did look right and it fit worse. Every time I looked at that suit hanging in the closet I got mad, so I finally gave it away. Since I still needed a suit, I went to a store that didn't advertise price but pushed quality. Sure, I paid more, but I bought myself a suit that got me a few compliments and wore for years—at a price that was actually reasonable for what I got.

My experience reminded me of what John Ruskin said a long time ago: "It's unwise to pay too much, but it's still worse to pay too little. When you pay too much you lose a little money—that is all. When you pay too little you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do." (I learned the hard way.) Ole Ruskin went on with this gem: "... business prohibits paying a little and getting a lot—it can't be done. If you deal with the lowest bidder it is well to add something for the risk you run. And if you do that, you will have enough to pay for something better."

Whether it's clothes or pipe—the principle is the same. For over a quarter of a century we've been coating and wrapping pipe to last—"PUTTING PERMANENCE IN PIPE"—and that's what makes our service most reasonable in the long run.

MAYES BROS.

1130
McCarly

HOUSTON, TEXAS

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Directory of Technical Committees

(Continued from Page 5)

• T-6A-1 Epoxys

C. G. Munger, Chairman, Amercoat Corporation, 4809 Firestone Blvd., South Gate, Calif.

• T-6A-2 Chlorinated Rubber

F. Shankweiler, Chairman, Hercules Powder Co., Wilmington, Delaware.

• T-6A-3 Rubber, Elastomers and Heavy Linings

H. C. Klein, Chairman, B. F. Goodrich Co., Cuyahoga Falls, Ohio.

• T-6A-4 Vinylidene Chloride Polymers

A. E. Young, Chairman, The Dow Chemical Co., Midland, Michigan.

• T-6A-5 Phenolics and Furans

Forest Baskett, Chairman, 4334 Ella Blvd., Houston, Texas.

• T-6A-6 Polyesters

D. F. Siddall, Chairman, The United States Stoneware Co., Box 350, Akron, Ohio.

• T-6A-7 Fluorocarbons

J. J. Onedrejin, Chairman, E. I. DuPont de Nemours & Co., Inc., Wilmington, Delaware.

• T-6A-8 Rigid Vinyls

C. G. Munger, Chairman, Amercoat Corporation, 4809 Firestone Blvd., South Gate, Calif.

T-6B Protective Coatings for Resistance to Atmospheric Corrosion

L. L. Sline, Chairman; Sline Industrial Painters, 2612 Gulf Terminal Drive, Houston, Texas.

Howard C. Dick, Vice Chairman, Products Research Service, Inc., Box 6116, New Orleans, Louisiana

T-6C Protective Coatings for Resistance to Marine Corrosion

Raymond P. Devoluy, Chairman, The Glidden Co., Room 1310, 52 Vanderbilt Avenue, New York 17, New York.

R. F. Daw, Vice-Chairman, The Texas Co., 135 East 42nd St., New York 17, N. Y.

T-6E Protective Coatings in Petroleum Production

J. L. Robertson, Chairman, Phillips Petroleum Co., Bartlesville, Oklahoma

T-6G Surface Preparation for Organic Coatings

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S. C. Frye, Vice Chairman, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

T-6H Glass Linings and Vitreous Enamels

G. H. McIntyre, Chairman, Ferro-Enamel Corp., Harvard & 56th Street, Cleveland 5, Ohio

T-6K Corrosion Resistant Construction With Masonry And Allied Materials

L. R. Honnaker, Chairman; E. I. du Pont de Nemours & Co., Inc., Engineering Department, Louviers Building, Newark, Del.

George P. Gabriel, Vice-Chairman, Atlas Mineral Products Company, Mertztown, Pa.

T-6R Protective Coatings Research

Robert H. Steiner, Chairman, Atlas Mineral Products Co., Mertztown, Pennsylvania

Joseph Bignor, Vice-Chairman, Steel Structures Painting Council, Mellon Inst., 4400 Fifth Ave., Pittsburgh 13, Pa.

Regional and Sectional Officers—Changes

• Corpus Christi Section

Paul H. Laudadio, Chairman; Briner Paint Manufacturing Company, 3713 Agnes Street, Corpus Christi, Texas.

Kenneth R. Sims, Vice-Chairman; Gas Division, Department of Public Utilities, Corpus Christi, Texas.

Robert C. Dill, Secretary-Treasurer; Reynolds Metals Company, P. O. Box 109, Corpus Christi, Texas.

Fred W. Hodgson, Trustee; Johns-Manville Sales Corp., 401 N. Touchea Street, Corpus Christi, Texas.

• New Orleans-Baton Rouge Section

J. R. MATHERNE, Chairman; Southern Bell Telephone & Telegraph Co., Communication Building, 1215 Prytanla St., New Orleans, Louisiana.

LEE N. SPINKS, Vice-Chairman; Catholic Protection Service, 1639 Robert St., New Orleans, Louisiana.

R. M. ROBINSON, Secretary-Treasurer; Continental Oil Company, Box 6158, New Orleans, Louisiana.

C. L. BARR, Trustee; Shell Oil Co., Box 271, Donaldsonville, Louisiana.

• San Diego Section

Dallas G. Raasch, Chairman; La Mesa, Lemon Grove, Spring Valley, Irrigation Dist., Box 518, La Mesa, California.

F. O. Waters, Vice-Chairman; San Diego City Water Dept., Div. of Engineering, Room 903, Civic Center Bldg., San Diego 1, California

Norman Beinfeld, Secretary-Treasurer; California Water & Telephone Co., 19 West 9th St., National City, California.

• Southwestern Ohio Section

Alfred D. Jense, Chairman; Ampco Metal, Inc., Rose-lawn Center Bldg., Reading & Section Roads, Cincinnati 87, Ohio.

S. Clifford Jones, Vice-Chairman; Cincinnati Gas & Electric Co., 2120 Dana Ave., Cincinnati 7, Ohio.

R. L. Wood, Treasurer; Cincinnati Gas & Electric Co., General Engineering Dept., P. O. Box 960, Cincinnati 1, Ohio.

L. M. Lederer, Secretary; Inner-Tank Lining Corp., 1097 Wade Street, Cincinnati, Ohio.

• Toronto Section

W. M. Kelly, Chairman; Consumers' Gas Company of Toronto Ltd., 19 Toronto Street, Toronto 1, Ontario, Canada.

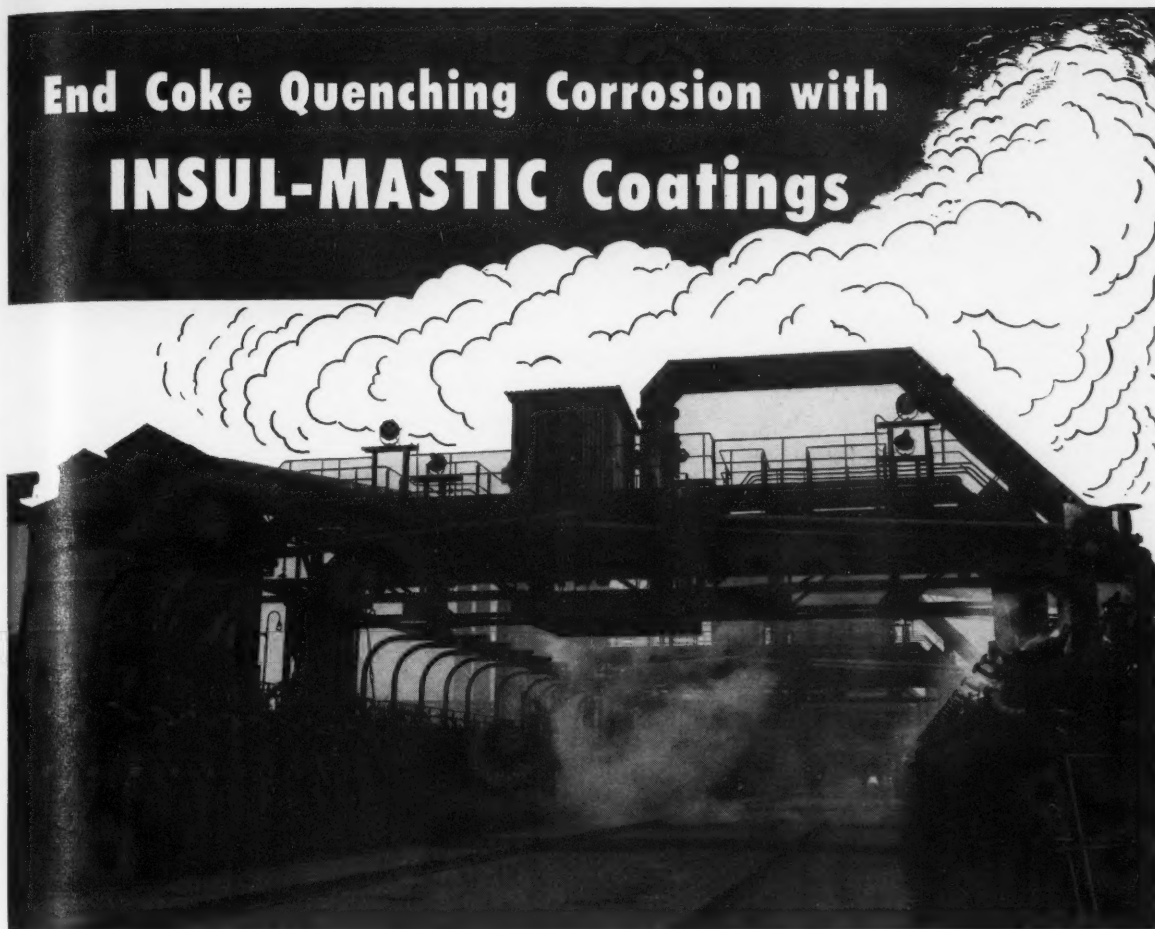
A. H. Carr, Vice-Chairman; Koppers Corp., Commerce & Transportation Bldg., 151 Bay Street, Toronto 1, Ontario, Canada.

Wm. G. Burks, Secretary; Corrosion Engineer, Trans-Northern Pipe Line Co. Ltd., 696 Yonge St., Toronto, Ontario, Canada.

H. A. Webster, Treasurer; Corrosion Engineers, Corrosion Service Ltd., 21 King St. East, Toronto, Ontario, Canada.

The Directory of Regional and Sectional Officers was published last in the April issue of Corrosion on Pages 4-6. The list here consists of changes and additions which have been made since that publication.

End Coke Quenching Corrosion with INSUL-MASTIC Coatings



Top-view of a U. S. Steel Corp. coke battery at Clairton, Pa., coated with INSUL-MASTIC.

Where do you need a protective coating? Our technical engineers can tell you. Write for information about this consultant service before planning to build or coat.

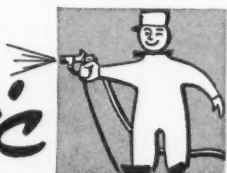
Here is the top-side of a coke battery. A carload of burning coke has just been quenched. Steam is drifting over all metal equipment in the area. Once this would have meant severe corrosion, but now INSUL-MASTIC protects this equipment.

INSUL-MASTIC coatings are ending coke quenching corrosion in steel mills and chemical plants everywhere. They are extremely durable and not affected by corrosive industrial atmospheres. INSUL-MASTIC coatings now in coke battery service six years prove that many, many more years of life can still be expected. INSUL-MASTIC is a *Superior* bituminous coating having carefully selected mineral fillers. It is spray applied $\frac{1}{16}$ " to $\frac{1}{8}$ " thick.

Throughout the nation, mills and plants having coke battery operations are specifying INSUL-MASTIC. They are coating all pipes, tanks, beams and other equipment normally corroded by industrial atmospheres.

Write today for the name of your nearest INSUL-MASTIC representative.

Insul-Mastic



Think first of the coatings that last!

Representatives in Principal Cities

CORPORATION OF AMERICA • OLIVER BUILDING, PITTSBURGH 22, PA.

A COMPLETE LINE OF FIELD-PROVED COATING PROTECTION PRODUCTS!

only from Carey

NOW—from one source, get everything you need to assure positive, lasting coating protection under all conditions of soil and terrain! Only Carey offers this complete line, backed by over 78 years of leadership in manufacturing and research.

CAREY GLASS To reinforce the coating, toughen and harden it to resist cold flow. Made from uniform drawn fibers laid in a pattern tested and found superior for strength characteristics.

2 CAREY ASBESTOS PIPELINE FELT Effectively shields the reinforced coating against the forces that cause soil stress, pressure points and cold flow . . . shield field-proved in over a quarter of century of service.

3 CAREY PIPELINE PADDING The original padding, developed for pipeline protection. So strong and flexible that it bends to conform with the shape of the pipe, without grooving and weakening.

Proper protection of your coatings is assured when you specify the complete line of Carey coating protection products—every one fully laboratory tested and job-proved. Ask your Carey Sales Engineer or write direct.

You Need This Valuable Free Booklet

A discussion of protective coatings for pipelines by a corrosion engineer for men faced with pipeline protection problems. Fill in coupon and mail today for your FREE copy.



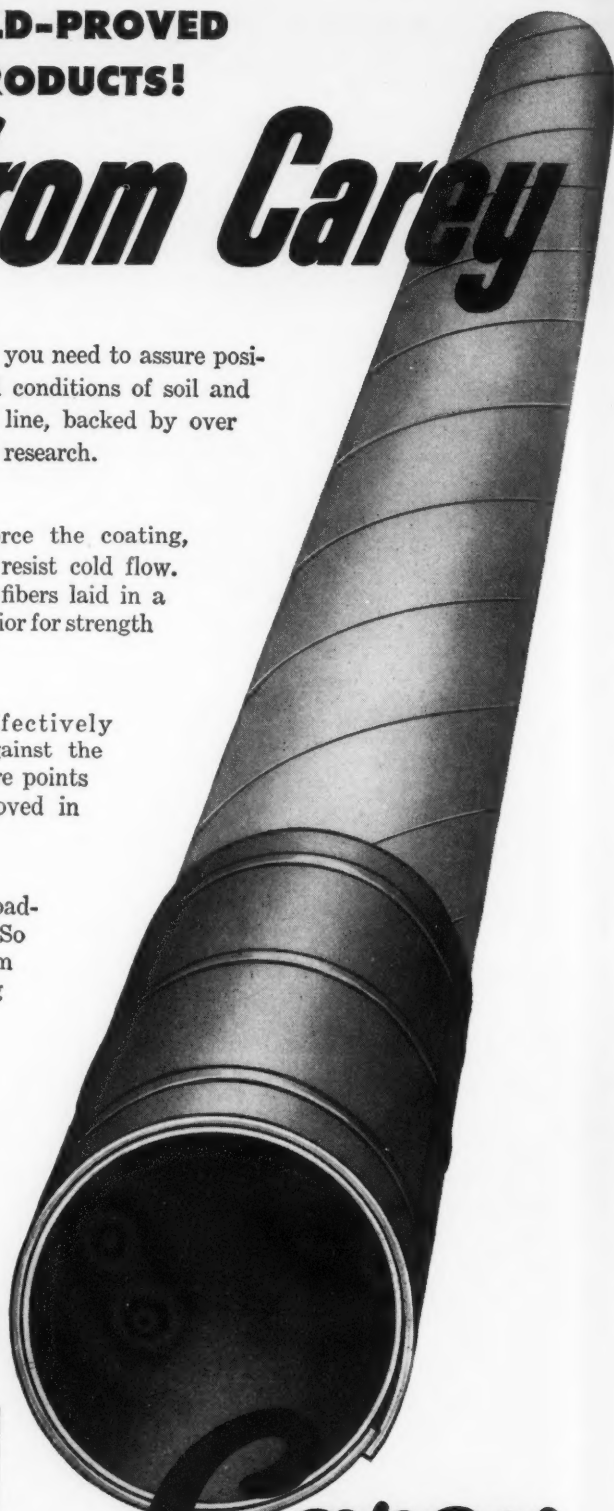
The Philip Carey Mfg. Company
Lockland, Cincinnati 15, Ohio
Department C-5

Gentlemen: Please send me a FREE copy of booklet, describing techniques and materials recommended for protective coating of pipelines. I understand there is no obligation on my part.

Name

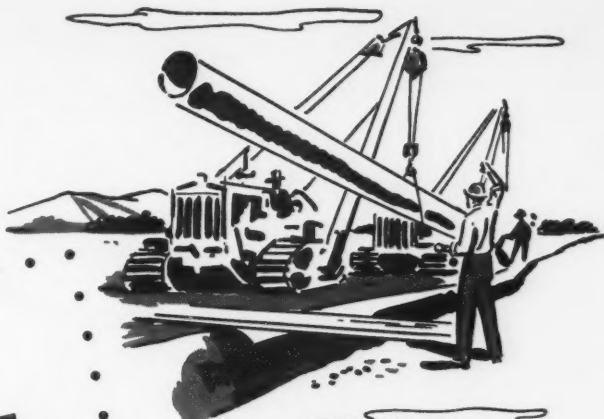
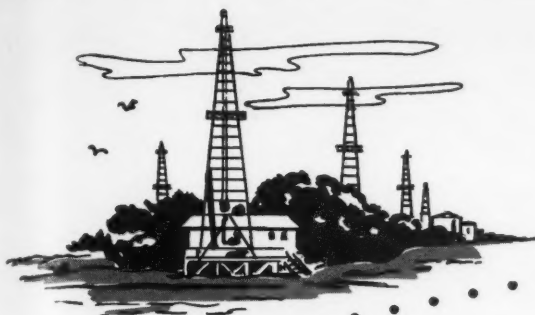
Address

City Zone State

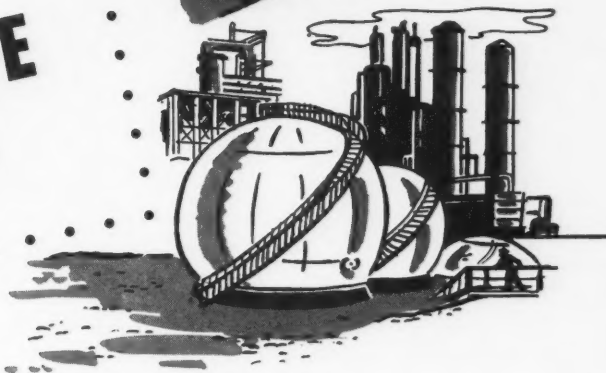


Carey

The Philip Carey Mfg. Company, Lockland, Cincinnati 15, Ohio
ASBESTOS—ASPHALT—MAGNESIA PRODUCTS



**PROTECT
TANK and PIPE
INTERIORS**



Use *Copon* . . . the revolutionary EPOXY RESIN COATING



Here are the reasons why "Copon" is attracting the attention of leading corrosion and petroleum engineers:

- It has exceptional tenacity, will adhere to metal surfaces longer and under more difficult conditions than any other coating yet tested.
- It is abrasion-resistant and has proven low erosion rate.
- It gives positive protection against rust and corrosion, also the chemical effects of crude oil, natural gas and salt water.
- It has amazing flexibility and elasticity.
- It provides a silky smooth, even surface that increases line flow by reducing friction.
- It is easy to apply by spray, brush or pig method.



COAST Paint & Lacquer Co. Inc.

P. O. BOX 1113

HOUSTON, TEXAS



Johns-Manville

TRANTEX *polyvinyl* **TAPE**

gives lasting protection against corrosion

YOU CAN MAKE emergency repairs quickly and economically right in the field with Johns-Manville Trantex Tape. This pipeline protective material is especially suitable for repairing damage to enamel coatings or holidays in coatings.

Trantex is recommended for field coating the joints of mill wrapped pipe. It also has many advantages for coating lateral lines and short runs where heavy duty coating equipment is not available. Save on emergency coating repairs too, by keeping a supply of Trantex in your warehouse for rush requirements.

Trantex Tape is easily applied by hand or simple wrapping devices. It is a durable plastic, cold-applied tape, with a pressure sensitive adhesive that sticks on contact, bonds tightly to enamel coatings or bare or primed steel. Trantex Tape provides uniformly high electrical resistance.

J-M Asbestos Pipeline Felt is a durable shield for pipe line enamels. Proven in use for protecting enamel

coating from cold flow under stress. It often is applied over Trantex Tape, for extra protection in rocky areas. Rotary type wrapping machines apply the felt and Trantex Tape in one operation.

For more details write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ont.

PROPERTIES OF TRANTEX TAPE

	*V-10	**V-20
Dielectric Strength per mil thickness Approx.	1,000 V	1,000 V
Insulation Resistance, greater than (ASTM-D-257-49)	100,000 megohms	100,000 megohms
Temperature Limit	200 F	200 F
Adhesion oz. per inch width	30	20
Tensile Strength lbs. per inch	30	56
Elongation at Break	250%	300%

"Trantex" is a black polyvinyl tape. It is available in two thicknesses—
 *V-10 is a 10 mil tape for average conditions, and
 **V-20, is a 20 mil thickness for use where a more rugged coating is specified such as to repair enamel coatings.



Johns-Manville TRANTEX *polyvinyl* **TAPE**



News about COATINGS for METALS

Metallic Organic Decorative Protective

Protective plastisols gain new versatility

Ucilon Protective Coatings solve many problems

A variety of Ucilon* Protective Coating Systems, using either air-drying or baking coatings are available to handle problems that cannot be solved with plastisols. Applied like ordinary paint, Ucilon Coating Systems resist the same corrosives as plastisols and even some that plastisols do not withstand. The line includes systems based on vinyl, phenolic, chlorinated rubber and other chemical resisting coatings. Detailed information is provided in Bulletin MC-8. Send for it—no obligation.

*Trade Mark

Four types of drum linings handle most needs

Protection against drum corrosion and contamination of product is being obtained by many major steel drum suppliers by four basic types of Unichrome Drum Linings.

These include: (1) Phenolic base linings which are well suited for packaging solvents, oils, acid products and are used extensively in shipping detergents. (2) An epoxy resin base lining that not only gives essentially the same chemical resistance as the phenolics but also better flexibility and alkali resistance. (3) Vinyl base linings which are used effectively for packaging foods as well as caustics, latex, potable mineral oils and the like. (4) Plastisol drum linings which resist a wide range of products and are good for multiple trips.

Bulletin DL-2 gives you more details.

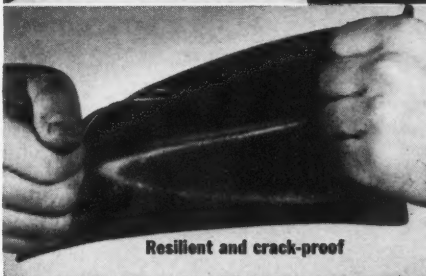
UNITED CHROMIUM, INCORPORATED

100 East 42nd Street, New York 17, N. Y.
Waterbury 20, Conn. • Detroit 20, Mich.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.

Advantages of Unichrome heavy-duty vinyl compounds now obtainable even with sprayed coatings



Thick, flexible film



Resilient and crack-proof



Resists many corrosives

PLASTISOL compounds are liquids, which when heat cured, build up vinyl plastic finishes that look and feel like rubber, but there the resemblance ends. Plastisols offer truly remarkable chemical resistance, which is further fortified by the tough, substantial film thickness achieved in one coat.

SEAMLESS, THICK-FILM PROTECTION

Any metal surface that can be uniformly baked can now be strongly protected against severe and corrosive service conditions by Unichrome 4000 Series Plastisol Compounds—or the new Coating 5300. The first practical sprayable plastisol, Unichrome Coating 5300 fills the need for a plastisol suitable for application to products too large to be dip-coated.

A 20 mils thick, non-sagging coat can be applied even to cold vertical surfaces in just one application with

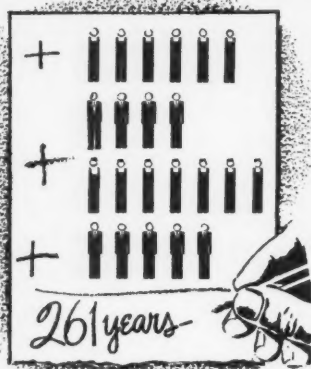
Coating 5300. That's 5 to 20 times thicker than ordinary coatings. Unichrome Series 4000 Plastisols, which are applied by almost any other conventional method, produce coatings up to $\frac{3}{16}$ " thick. Plastisols can do jobs for which sheet materials have been used.

CHEMICAL RESISTANCE OF VINYL

Unichrome Plastisols offer seamless and pore-free protection against acids, alkalis, water, salt solutions and many other corrosive agents. They bake into an abrasion-resistant resilient coating that doesn't crack, chip or tear. With such protection, ordinary metals can often be used in place of costly alloys.

The chemical resistance, physical toughness, electrical insulating properties, and speed of curing of Unichrome Plastisols combine to offer engineers a new tool for protection and finishing. Send for Bulletin VP-1.

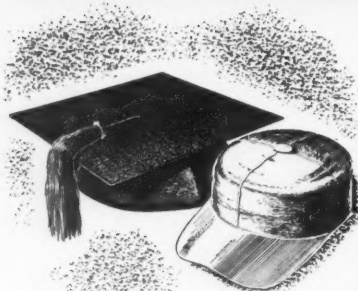
Things That Money Can't Buy!



STICK-TO-IT EXPERIENCE



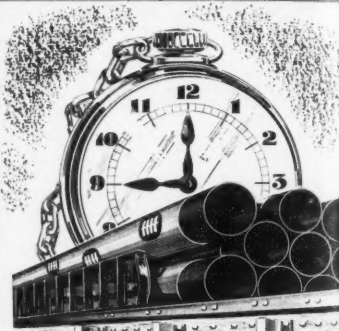
'ROUND THE CALENDAR DEPENDABILITY



TWO-WAY ABILITIES



PIONEER'S KNOW-HOW



ON TIME SERVICE

IN EVERY INDUSTRY there's a leader with certain intangibles that tip the balance between superior and mediocre results. In the pipe-protection industry that leader is Hill, Hubbell & Company—and the intangible "things that money can't buy" add up to a superior type of service which can come only from longer experience and technical knowledge. This pioneer's know-how . . . *in addition* to the most modern processes and equipment . . . keeps Hill, Hubbell well out in front.

HILL, HUBBELL and COMPANY

Factory Applicators of Pipe Coatings and Wrappings

DIVISION OF GENERAL PAINT CORPORATION

3091 Mayfield Road • Cleveland 18, Ohio



WmSON STYLE 4 THINSULATOR

The "THIN" insulator for pipe in casing

Clearance insures free movement
into casing
THINSULATOR band, flexible steel
lined with synthetic rubber.
Band clamped with steel stud bolts.

steel runners
pipe line
casing

SIZES
6 x 10
to
36 x 40

THINSULATORS EQUALLY SPACED THRU CASING

A SNAP TO INSTALL
just snap on pipe
tighten studs . . .

WmSON CENTERING CRADLE

short massive INSULATOR centers pipe
at casing end permitting easy installation of
"Z" BUSHING



- carries weight of backfill dirt and insulates pipe from casing
- EASY TO INSTALL: Simply lift pipe and slip into place

SIZES: any combination of
pipe and casing sizes.

PIPE LINE

CASING

PIPE LINE

Here's why...
Pipe line construction specs. include
WmSON BUSHINGS, INSULATORS & CRADLES
for cased crossings . . .

They are "ENGINEERED" for
LASTING ECONOMY.

WmSON "Z" BUSHING

OVERSIZED RING
SLIDES EASILY OVER
CASING END

THREADED TERMINALS
IN CABLE UNION

PLASTIC-COVERED
AIRCRAFT CABLE

CUT-A-WAY
VIEW SHOWING
TOUGH, THICK
SYNTHETIC RUBBER

NO SHIELD REQUIRED
to protect tough sleeve
from rocky backfill

SIZES:
FOR PIPE 6" AND UP
IN CASING 4" OR 6"
LARGER



T.D. Williamson, Inc.

P. O. BOX 4038

TULSA 9 OKLAHOMA

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If you **MUST** stop Corrosion **KEL-F® PLASTIC WILL**

*KEL-F Plastic Molded
and Fabricated
Valve Linings,
Valve Diaphragms,
Gaskets, Ring Seals,
Gauge Crystals,
KEL-F Dispersion Coated
or Laminated Lined
Tanks, Vessels, Reactors,
Piping and Tubing
can protect your
plant equipment against
chemical corrosion*



KEL-F Fluorocarbon Plastic is the best non-permeable, corrosion-proof material available today. It is inert to virtually any type of chemical attack—including mineral acids, oxidizing agents as well as strong caustics. When nothing else will protect equipment, KEL-F Plastic usually will.

HERE ARE SOME OF ITS OUTSTANDING CHARACTERISTICS: **Temperature Tolerance**

Exhibits satisfactory properties over a temperature range of approximately 710°F. (–320°F. to 390°F.)

High Compressive Strength

Pressures of 8,000 psi result in only 4% to 5% permanent set. Line seals are retained longer when gaskets and O-ring seals are made of KEL-F Plastics.

Non-Adhesive

KEL-F Plastic is non-wetting even after long periods of immersion. Surface is anti-fouling when in contact with even the most viscous liquids.

KEL-F Plastic is a thermoplastic and easy to fabricate. It is readily molded by extrusion, transfer and injection. Available in sheets, rods, tubing and film, it can be fabricated, heat formed, machined and heat-sealed by a growing list of experienced fabricators.

New! KEL-F Plastic Dispersions

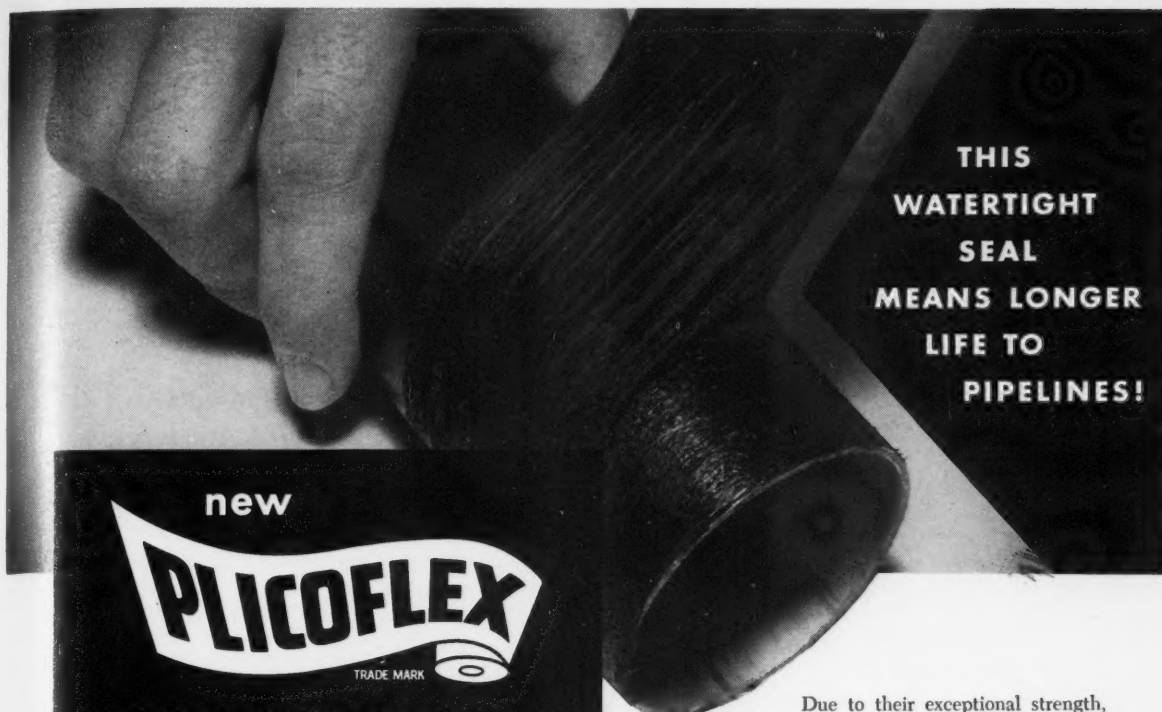
KEL-F Plastic Dispersions have been developed for bake-coating of metallic surfaces that must be corrosion resistant, anti-adhesive and electrically non-conductive. These Dispersions can be applied by spraying, spreading or dipping.

The full story of what KEL-F will do for you is worth having. Write or call for additional information.



THE M. W. KELLOGG COMPANY
Chemical Manufacturing Division, P. O. Box 469, Jersey City, N. J.
SUBSIDIARY OF PULLMAN INCORPORATED

®Registered trademark of The M. W. Kellogg Company's fluorocarbon polymers.



new
PLICOFLEX
TRADE MARK
 Polyvinyl Chloride Tapes

**Here are features old-style
 tapes can't match**

- Exceptional physical and dielectric strength.
- High resistance to shock, impact, acids, alkalies, and soil stress.
- Unequalled bond to metal pipe surfaces.
- Positive seal at helix of spiral.
- Extra thickness for extra protection.
- Low initial cost, lower final cost.

Due to their exceptional strength, new Plicoflex Polyvinyl Chloride Tapes can be wrapped tighter, expelling air and moisture and filling in imperfections in pipe surfaces to effect an unexcelled bond.

The photo above shows Plicoflex No. 330 tape being stripped from pipe. Note that the adhesive will not disbond from either the pipe surface or tape. No air bubbles or moisture droplets here! Pipe surface is effectively sealed against soil or atmosphere.

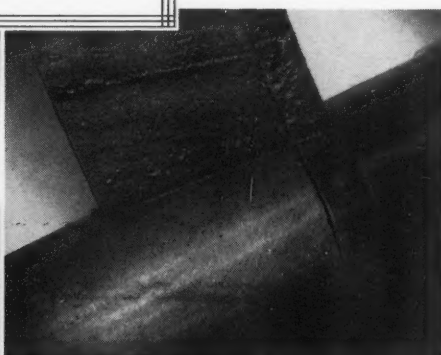
Illustrated below is Plicoflex No. 340, a laminated pvc-and-rubber tape which provides the added protection of a thick, continuous sheath of rubber firmly fused to the pipe surface.

Plicoflex Tapes are available in black, white, and 6 colors, providing a virtually maintenance-free color-coding system for above-ground installations.

Superior Plicoflex Adhesives of asphalt, coal tar or Neoprene base materials are available to suit your particular requirements.



Plicoflex No. 340, applied with adhesive primer, demonstrates its superior bonding and sealing qualities.



Plicoflex No. 340, applied bare, still demonstrates its superior bonding and sealing qualities.

For more detailed information on the Plicoflex System, mail the coupon today.

PLICOFLEX, INC.
 1566 E. Slauson Ave.
 Los Angeles 11, Calif.
 More info on PLICOFLEX, please.

NAME _____
 COMPANY _____

ADDRESS _____
 CITY _____ STATE _____

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



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<i>Treasurer</i>	R. A. BRANNON Houston, Texas
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Topic of the Month

"Hot Fence" Is Unexpected Ground Bed Hazard*

By FRANK E. STETLER*

WHEN WORKMEN setting steel pipe posts for a fence around Berryville School yard noticed mild electrical shocks upon touching the posts and much more severe shocks when an attempt was made to connect the longitudinal pipes between tops of the posts, a police broadcast was made that the wire fence around the school was electrified at 180 volts and was dangerous to the public. When word of the broadcast reached the offices of the telephone company concerned with electrolysis affairs, it was realized that the school yard was adjacent to the ground bed for a rectifier providing cathodic protection for nearby lead-sheathed underground toll cables. An immediate investigation was launched.

Inspection showed that workmen had inadvertently located three posts with dangerous geometry of tangency between the wet concrete and the buried electrodes. Thus the pipes set in wet concrete became in effect aerial extensions of the buried electrodes. To eliminate the hazard, the rectifier was deenergized until the ground bed could be relocated.

The ground bed, constructed in 1938, consisted of eight railroad rail sections in coke breeze backfill, set vertically 10 feet apart in a line parallel to that of the school property. The rectifier operated at about 90 volts DC.

Figure 1 shows location of three

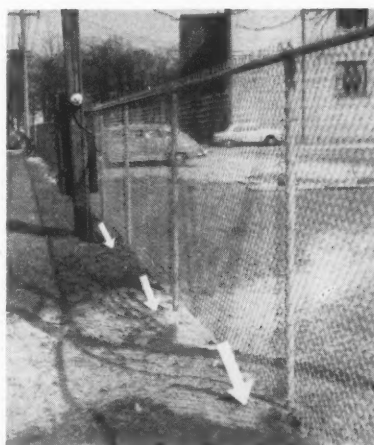


Figure 1—Arrows show locations of the buried electrodes.



Figure 2—Paper circle shows location of the electrode coke and tangency with the fence post concrete.

buried electrodes in relation to the fence. The paper circle in Figure 2 is placed directly above the electrode coke and shows the tangency with the fence post concrete. In at least one case the concrete protruded about an inch into the coke

cylinder, providing a substantial contact area.

Electrical Tests

Tests showed a 30-volt potential difference between the fence and the earth above a buried electrode. Touching the two points with the fingers produced a mild shock sensation. With 90 volts and two amperes drain to a test set up of five ground rods located six feet from and parallel to the fence, voltage gradients between the fence and earth surface were measured. Readings two and four feet from the fence showed seven and 14 volts respectively, which produced no shock sensation with dampened fingers.

The reported 180 volts was measured by an electrician unfamiliar with the circuitry, probably with a rectifier-type voltmeter, which, on an AC scale will indicate approximately double an applied DC voltage, or zero if polarity is reversed.

Installation Is Corroded

Of added interest from the corrosion viewpoint, it was found that this installation had suffered from corrosion. The tie wire connecting the rectifier to the eight rail electrodes had been corroded in two at the rectifier side of the splices at the fourth and sixth rails. This apparently was the result of failure of the moisture seal around the splices, permitting the copper conductor to become a sacrificial anode.

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A Practical Method for Cleaning and Descaling Cargo Tanks Contaminated With Black Oil Residues*

By J. F. MILLS,⁽¹⁾ F. E. COOK⁽²⁾ and H. S. PREISER⁽³⁾

THE SELECTION of a cleaning technique for the removal of oil contamination and scale from cargo tanks is dependent on many factors. The more important considerations include the extent and nature of the contaminant, extent and degree of scale formation, type of repair or alteration and the use for which the cleaned tanks are intended. Several methods for cleaning tanks are available, each having its own limitations and advantages. Sandblasting or gritblasting, for example, is excellent for scale removal in irregular and poorly accessible tanks but in general the process is noisy, expensive and dirty to handle. Electrolytic descaling, on the other hand, is clean, economical and quiet but it is not readily adaptable to irregular, confined tanks. Large rectangular tanks present no problem when cleaned by the electrolytic process.

In either method of scale removal it is necessary to gas free the tanks and remove oil residues prior to commencing operations. The decontamination of tanks containing heavy fuel oils can be accomplished by injecting hot seawater, hot oil or chemical solutions through revolving nozzles under pressure (Butterworthing) or by the vapor injection-emulsion cleaning process. The former cleaning technique, using hot sea water under pressure, often is accomplished at sea. The use of hot oil or chemicals results in a more thorough cleaning job but introduces complications in the handling procedure. Vapor injection-emulsion cleaning is mainly a ship-yard technique but it can accomplish difficult oil removal with a minimum of time, effort and expense.

The method described in the paper, developed at the Puget Sound Naval Shipyard, is particularly applicable to the removal of heavy scale formation contaminated with black oil residues. The first phase entails the removal of the black oil residues by means of a vapor injection-emulsion cleaning technique. The second phase which follows, removes the rust and corrosion products by means of the electrolytic descaling process. The laboratory and field investigations which were undertaken to develop practical field data for the electrolytic descaling process are described in the paper published in the November 1954 issue of the *Journal*.¹ The bibliography of the previous paper contains 28 background references on the subject.

In cases where tanks are being converted from

Abstract

A method for removing black oil residues from tanks is described. The cycle of operations includes ventilation of the tank, removal of existing sludge, steaming at 100 psi until temperature reaches 175-180 F, injection of an emulsion cleaner through a specially prepared jet, injection of cold water, cooling of the tank and washing down with high pressure jets of fresh water. The injector used is described and formula for emulsion cleaner given. Electrolytic descaling is effected by making the inner tank walls the cathode in an electrical circuit moving through a suitable aqueous electrolyte filling the tanks.

heavier oil cargo to aviation gasoline, all pipe lines should either be removed and cleaned by regular cleaning methods in the pipe shop or they should be "rattled," flushed with hot water or chemicals, wiped or otherwise so treated as to insure complete removal of all traces of black oil, diesel oil, water, or kerosene from the inside of the pipe lines. This treatment should be extended not only to suction and discharge piping, but where necessary, to vent piping, steam smothering lines, leaky heating coils, pipe handrails, ladders and any other type of piping or structural joint or connection found within the tank. If the tank piping has a packed expansion joint, the packing should be removed and renewed with clean packing. In other cases, where contamination of cargo is not a problem, the exterior surfaces of the piping within a tank could be cleaned in place.

Vapor Injection—Emulsion Cleaning

The emulsion cleaning of fuel oil tanks by the vapor injection process is based upon the diffusion of finely divided particles of cleaner by the movement of steam to the relatively cold surfaces of the tank where condensation takes place and an emulsion is formed. Preheating by steam lowers the viscosity of Diesel oil, which is the solvent component of the emulsion cleaner and aids in the penetration of the emulsifying agent. Over-steaming, however, should be avoided since it raises the temperature of the side walls too much, thus lowering the condensation rate and decreasing the cleaner efficiency.

Tank Cleaning Procedure

There are six steps in the cleaning of an oil tank by this method, which are as follows:

- a) Ventilate the tank. This is done by a suction blower. The tube is extended to the bottom of the tank through the manhole. The displaced air is replaced by entrance of fresh air through the manhole. The ventilation should be continued until the space is declared safe for entrance.
- b) Remove sludge by pumping. Any type sump

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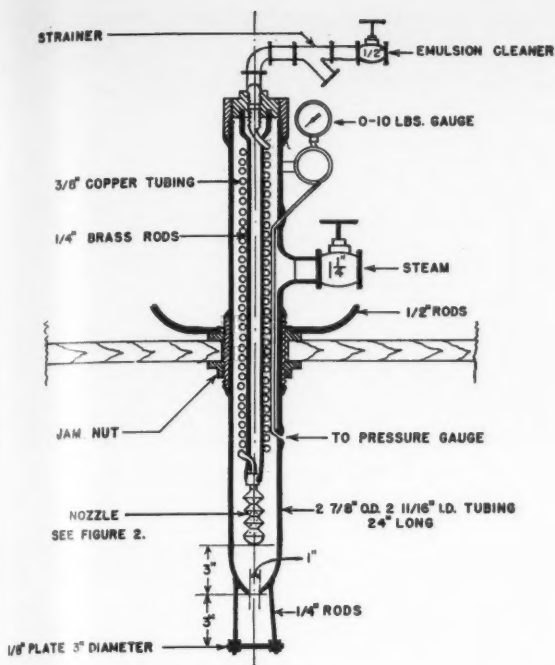


Figure 1—Chemical injector.

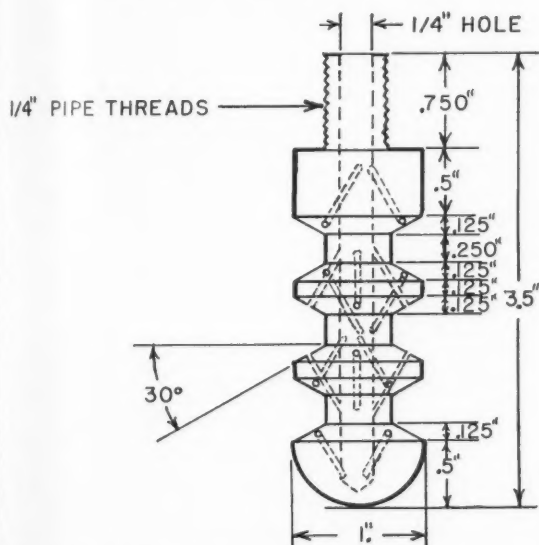


Figure 2—Nozzle. Note: Drill twenty-four 1/32 inch holes, four holes 90 degrees on each surface. Holes in opposite surfaces aligned exactly. Three groups of four pairs, each group 30 degrees offset.

pump that will lift the heavy sludge is satisfactory for this purpose. The pump should be placed in the tank and the suction hose extended to the lowest point in order to evacuate as much sludge as possible. After the sludge has been removed satisfactorily, the pump and all hoses should be removed from the space.

c) Open the tank vent to insure against building up a pressure when subsequent steaming takes place.

d)

1) Figures 1 and 2 show the chemical injector,

mounted on a portable manhole cover made of waterproof plywood which has the same dimensions as the regular manhole cover. This assembly is placed on the manhole and bolted down. It should be noted that the lower end of the injector extends below the level of the deck in order to obtain best results. A steam line of 1½ inches or larger is connected to the valve provided on the chemical injector. The steam pressure on the line should be 100 pounds per square inch.

2) Close all other openings except the vent, which should be left open at all times and admit steam at full pressure for one or more hours. The pressure gauge on the injector should show no pressure when steaming. If it does, shut off the steam immediately and check the tank vent. When the temperature, as indicated by the thermometer in the manhole cover, reaches from 175 F to 180 F the tank is ready for the injection of the emulsion cleaner.

3) A chemical injection pump to supply the emulsion cleaner to the injector must be available. The pump should be a positive displacement type with a capacity of approximately five gallons per minute at 100 psi. The exit side of the pump should be equipped with an adjustable pressure by-pass back to the intake of the pump. The pipe to the nozzle of the injector should be provided with a gauge so that the proper nozzle pressure can be determined and maintained by adjustment of the by-pass. The exit side of the pump should be connected to the chemical injector, the pump started and the emulsion cleaner pumped through the nozzle of the injector. The solution is forced through the nozzle at the rate of 3 gallons per minute.

4) The amount of cleaner required will depend upon the size of the tank being cleaned. It has been determined that 50 gallons will clean a 1200-barrel tank and 150 gallons will clean a 6000-barrel tank.

5) During the injection of the cleaner, the steam pressure should remain on the injector.

e) After the emulsion cleaner has been injected, cold water is run through the pump and lines to the nozzle for 15 to 30 minutes while steaming. This produces a wet steam and causes excessive sweating on the walls of the tank which emulsifies the oil and washes the emulsion to the bottom of the tank.

f) As soon as the tank is cool enough to enter, the tank should be washed down with a jet of high pressure fresh water. The sump pump should be lowered into the tank and the suction line placed in the lowest point. The pump should be started and the emulsified oil and water discharged from the tank. If the tank is washed down before it becomes completely cold, no wiping is necessary except in the lowest pockets. Wiping down with rags will be required to remove the final traces of oil which cling to the lowest points of the tank.

Description of Injector

The chemical injector (Figure 1) is designed to pre-

heat and atomize the cleaning solution for uniform mixing with the entering steam. The body of the injector proper, the steam side, is made of copper-nickel tubing to which are connected a pipe coupling, a standard all-thread pipe nipple and three brass rods supporting a deflector plate. A copper coil is silver soldered to support rods attached to the reducer bushing in the top of the injector body. The nozzle (Figure 2) is screwed into the coupling which is fitted to the bottom end of the copper coil. A steam valve is connected to the side of the injector. The injector is equipped with a 10-pound pressure gauge. The injector assembly is mounted on the plywood manhole cover by means of the jam nuts. The covers are manufactured to fit the various sizes and shapes of manholes encountered. A thermometer is mounted in the manhole cover after assembly. The entire unit weighs only 27 pounds and is easily handled by one man.

Formulation of Emulsion Cleaner

The emulsion cleaner is composed of an amine-oleate soap dissolved in Diesel oil. The composition of the cleaner is as follows:

- 2½ gallons oleic acid (red oil)
- 1 gallon triethanolamine or ½ gallon monoethanol-amine
- 45 gallons Diesel oil

In compounding the formula, the oleic acid is dissolved in the Diesel oil until a homogeneous solution is formed. Then the amine is added slowly with vigorous stirring in the proportions given above.

This amine soap solution is a liquid at normal temperatures but may gel in very cold weather. It is therefore advisable when compounding the cleaner, to use Diesel oil which has been warmed to at least 60 F. Cost of the cleaner is about \$30 per 100 gallons. In general, tanks of 50,000-gallon capacity require 50 gallons of cleaner. Tanks of 250,000-gallon capacity require up to 150 gallons of cleaner.

Electrolytic Descaling

The electrolytic descaling phase of the tank cleaning method consists of making the inner surface of the tank the cathode in an electrical circuit in which suspended fabricated steel grids or curtains are the anode. The tank is filled with sea water which functions as the electrolyte. When sea water is not available a 1½ percent salt solution may be substituted.

Existing data is based on a sodium chloride solution. However, there is no obvious reason why other electrolytes could not be satisfactorily employed.

Electrical energy is supplied by one or more low voltage (about 10 volts), high amperage (about 1200 amperes) DC welding generators, so that a resultant current density of about 0.5 to 1.0 ampere per square foot on the tank surfaces is maintained. For all practical purposes, the current passes from the anode through the electrolyte to the cathode. The length of time required to loosen the scale varies somewhat with the thickness of the scale and the current density. The time required is greater with heavier scale and less with greater current density. Best results are obtained with a current density between 0.5 and 0.7

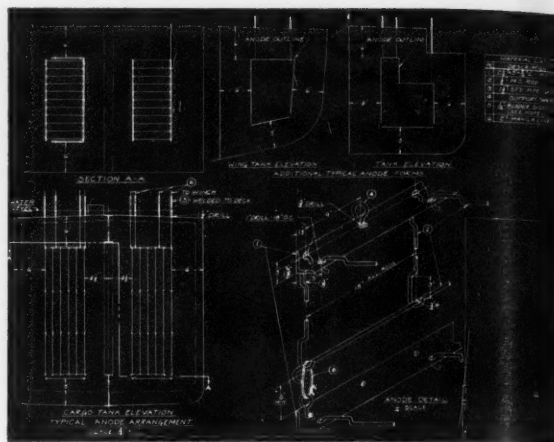


Figure 3—Notes: 1. Where section of anode comes within one foot of ship's structure, shield anode section with rubber, Pc. 5. 2. Omit anode rods where necessary to maintain clearance.

ampere per square foot for the side and top surfaces and a current density of about one ampere per square foot for the bottom of the tank. The time required for descaling tanks varies from 24 to 48 hours. For example, for tanks of 500,000 gallon capacity, seven welding generators (each rated at 1200 amps continuous duty) will do the job. One generator would be connected to the anodes for each bulkhead, one to the overhead anodes, and two in parallel to the bottom anodes.

Anodes

The anodes consist of curtains or grids of ½ to 5⁄8-inch diameter steel rods with hooked ends inserted into holes in angle iron framing or over 1-inch diameter rods. All parts of the anode are manufactured in the shop and the individual parts are then lowered through the tank manholes and assembled by hooking and clamping so that a minimum of welding is required in the tank (see Figure 3). The anodes are then readily disassembled after the tank descaling operation and reused in subsequent tanks until excessively reduced in diameter by electrolytic action. The anodes are so designed and suspended in the tank that all elements are spaced about six feet from each of the six tank surfaces.

The rods in the six planes of the anode curtains are spaced on 18-inch centers. (See Plate 1.) The grid is supported by a sufficient number of 2-inch sisal ropes through 1½-inch diameter holes drilled through the deck above the tank to hold the anode in the position previously described. Centered over each 1½-inch hole and welded to the deck are pieces of standard 1½-inch pipe of sufficient length so that they extend at least one foot above the highest level of the electrolyte in the completely filled tank. The anode supporting ropes will then pass through these pipes. (See Plate 2.) Lashing eyes for these ropes have previously been welded to the top angle iron frame of the anode. In the event that protruding members of the hull come closer than six inches to the anode, that portion of the anode should be protected with split rubber hose.

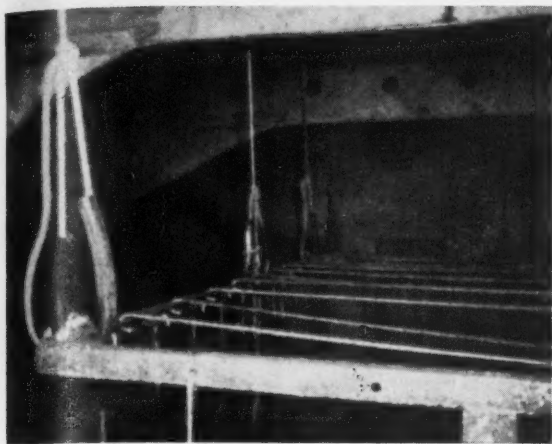


Plate 1—Suspension of anode grid in tank. View taken after 40-hour descaling periods.²

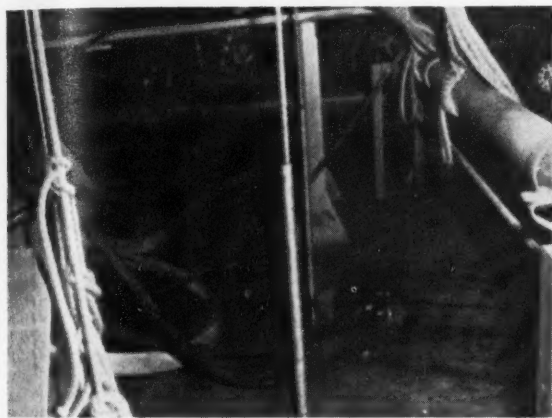


Plate 2—Arrangement of standpipes on deck for venting and for suspending anodes.

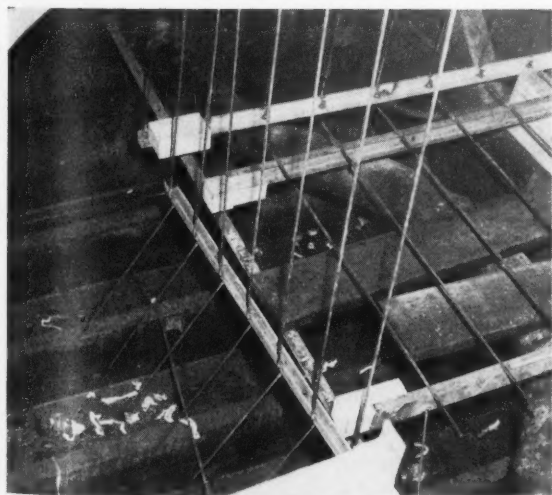


Plate 3—Grid anodes, showing extension rods for corners.

The anode may be manufactured and assembled as a single unit or two or more units may be used in a tank, depending upon the construction of the tank.

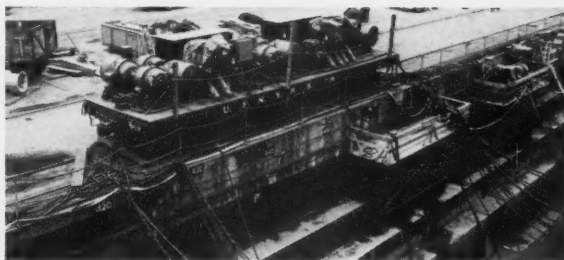


Plate 4—View of motor assembly from vessel.

A deep vertical keel and centerline deck beam may make two separate anodes in a single tank desirable. Also the throwing power of the anodes into corners and recesses can be improved by the use of anode extensions. (See Plate 3.)

Order of Procedure

After a ship is dry docked ready for cargo tank descaling, the following procedure is followed:

The first step depends upon the condition of the tank, the most recent cargo and whether or not the tank has been hot water washed at sea before coming in for tank cleaning. If the tank has not been hot water washed and its latest cargo was some type of black fuel oil, the tank is first cleaned as previously described. The tank is then tested again for explosive gases. When safe to do so, an opening is cut in the lowest part of the bottom of the tank for a ten-inch gate valve, which is bolted to the bottom plate. The tank is now ready for the installation of the anodes.

DC electrical generator capacity is furnished by a battery of motor-generator sets. (See Plate 4.) These are welding motor-generators with controls modified to make them suitable for the electrolytic descaling service. The modification consists simply of providing separate field excitation from a 70 VDC welding machine connected to each motor-generator to control current output. Maximum continuous rating of the motor-generators is 1200 amperes. The positive leads of these generators are brought into the tank and bolted to the top frame of the anode at points to give the proper distribution of current to the tank surfaces. Electrical jumpers are provided where necessary to aid in the current distribution. The bolted connections and exposed electrical cable lugs are painted with a coating of varnish to insulate them from direct contact with the electrolyte. The negative leads are attached to the shell of the ship with bolted lugs.

The tank is now filled with salt water to within 12 inches of top of coaming. The hydrogen liberated in the descaling process escapes through the pipes which also house the anode supporting ropes. Current should never be applied with tank only partially full of water. Apply generator load not to exceed 1200 amperes per generator at about 10 volts. Adjust current from 0.5 to 0.7 ampere per square foot of tank interior surface for side and top anode, and one ampere per square foot for bottom anode. Run at this load for 16 hours minimum, drain down, flush out scale taking care to remove all scale accumulations

on the bottom of the tank and refill with salt water. Reapply generators and continue descaling for 16 hours (minimum). Reverse the flow of electricity at half the former load for five minutes at the end of the final scaling operation. The tank then is drained completely by opening the 10-inch gate valve installed at the bottom of the tank. Flush the entire interior surface of the tank with salt water from the ship's fire mains, or from shore connection, leaving the drain valve open during the flushing operations. Electrolytic descaling is continued if necessary. Otherwise the interior tank surfaces are then hosed down with the fresh water.

Precautions

During the entire operation of descaling, precautions are taken to prevent explosions from hydrogen gas accumulations. Gas test readings are taken frequently in nearby spaces in proximity of the tank. "No Smoking" and "No Welding" signs are posted in the vicinity of the tank.

Where a vessel is to be electrolytically descaled while afloat and generators are located at the pier, the size of copper ground-return cables should be at least 1,000,000 circular mils per 1000 amperes. This precaution will prevent possible stray current damage

to the hull. The electrolytic method of descaling rust from tanker compartments has been found to be quieter, cleaner, quicker and more economical than other conventional cleaning techniques.

Acknowledgments

The work at the Puget Sound Naval Shipyard was supervised by Mr. J. F. Mills, Head of Laboratory Branch, Code 370. Shop work was performed under the direction of Cdr. A. C. Lombardi, U.S.N., Shop Superintendent. The principle investigators on the various phases of the projects were Mr. W. H. Miles, Test Engineer, Mr. G. F. Pettengill of the Chemical Engineering Unit and Mr. R. E. Canfield of the Chemical Group.

The recommendations and opinions expressed in this article are those of the authors and not necessarily those of the Navy Department.

Bibliography

1. F. E. Cook, H. S. Prieser, J. F. Mills, Electrolytic Descaling—An Electrical Method of Rust Removal From Tanker Ship Compartments, *J. Soc. Nav. Eng.*, **68**, No. 4, 1005-1050 (1954). Nov. *Corrosion*, **11**, No. 4, 161t-181t (1955) Apr.
2. All illustrations for plates courtesy of Bureau of Ships.

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Figure 1—Placing wood lining in steel fitting.

Advantages of Wood Lined Steel Pipe In Corrosive Services*

By E. H. BRONSTEIN*

Introduction

WOOD, one of the earliest materials of construction, is still extensively used as a material for transporting corrosive or abrasive substances.

The hand-hollowed log evolved into an improved construction¹ toward the approach of the nineteenth century: A pipe built of staves, cut to accurate curvature and to true radial planes and held secure by iron hoops, straps, or wire for strength.

When extensive use of wooden pipe in waterworks practice and industry began to yield to cast iron and steel pipe around the close of the nineteenth century, properties found especially valuable in wood pipe caused it to be retained for applications where iron and steel proved not as fully serviceable or as economical or where ferrous metals were deemed altogether unsuited. Some of these properties are:

1. A natural immunity to electrochemical corrosion. Since no ions from dissolving metal are present serious contamination of the fluid in the pipe by corrosion products is therefore precluded.
2. Inherent resistance to many chemical exposures that affect steel adversely or render the use of suitable alloys economically prohibitive.
3. Characteristic wear-resistance of certain species like maple² and beech³ which are known to withstand prolonged abrasive action.
4. A distinctive capacity for lowering pipe friction, assuring smooth fluid flow with increased delivery.

Wood pipe is used to an extent far greater than is generally supposed, especially in the more abrasive and corrosive operations. Typical materials handled by wood pipe or wood linings are: Aggressive waters from mine drainage and from chemical processes; abrasive slurries of many origins, wood pulps of virtually all descriptions, natural and processed brines; acid fumes, gases and vapors; refinery waste liquors and acid, alkaline and saline solutions. These uses are detailed in Table 1.

Abstract

Wood-stave and especially wood-lined steel pipe is extensively used to transport corrosive and abrasive substances at temperatures up to 185 F. Wood is especially useful in handling pulp suspensions, pulp-mill wastes, mine wastes, dilute mineral acids and dilute caustic soda solutions. Its acceptable pH range is from 2.5 to 11. It is not recommended for use with strong oxidizing agents, concentrated mineral acids or highly alkaline or caustic solutions. It is used successfully to exhaust many kinds of corrosive fumes and vapors.

Short term laboratory and lengthy service experience have shown that even under pressures up to 100-200 psi liquids seldom penetrate halfway through standard thicknesses of staves. This keeps corrosion at the wood-steel interface of wood-lined pipe at a minimum.

Other assets are sustained low friction coefficients and a degree of insulation from temperature. 4 tables, 16 references and bibliography.

First Recorded Installation in 1891

Because tensile strength of wood perpendicular to the grain is considerably less than that of steel, a bored log or a pipe made of weakly bound staves will exhibit no resistance to internal pressure above 25 psi and must depend upon steel bands or wire for extra strength. Because steel banded wood pipe serves pressures up to 125 psi, the need for greater strength to meet higher operating pressures and other mechanical demands normally fulfilled by sturdier pipe, led to the adoption of the wood lined steel pipe design in 1928 by The Michigan Pipe Company, developed during a program of engineering design headed by Henry B. Trombley, senior mechanical engineer.

Independently of this however, in 1891 the first wood lined steel pipe installation⁴ on record was fabricated under the auspices of the City of Newark, New Jersey Water Division. This consisted of one 42-inch and one 48-inch steel pipe, each securely holding a complicated wood stave lining of varying thickness, along a tapering diameter, terminating as

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TABLE 1—Service Experience With Wood Linings

Materials Group	Industry	Piping Service	pH	Temp. Degree F.	Pressure PSI	Velocity Ft./Sec.
Aggressive Waters	Coal-Mining	Acid mine water: (free H_2SO_4 with dissolved sulfates and suspended silica)	3.0-4.0	Atm	up to 250	up to 10
	Petro-chemical	Water exhaust containing 0.5% H_2SO_4 and 0.15% SO_2	....	160 F	....	....
	Pulp and Paper	De-mineralized water	....	....	....	....
		Acidulated water containing 0.4% HCl with traces of chlorine	4	90 F	....	....
Pulps and Related Suspensions	Pulp and Paper	White-water: largely water that has been separated from pulp suspensions usually carrying small amounts of fibre with residues from digesting and bleaching liquors.	5.5-6.5	125 F Max.	75 Max.	6 Max.
		Sulfite pulp, Sulfate pulp, Soda pulp, Mechanical pulp, Bleached and unbleached: Washed and unwashed up to 10% aqueous suspensions	2.5-7.0	125 F Max.	75 Max.	6 Max.
Abrasive Slurries	Cork Manufacture	Water-logged cork dust, 10% suspension	6.0	Atm	....	....
	Coal-Mining	Coal refuse—14 mesh 20% solids	4-5	Atm	100	10
	Silica-Mining	Sand slurry 25% solids—20 mesh	....	....	150	16
	Steam-Electric Power Generation	Fly ash slurries 10% solids	....	100 F	up to 50	6
	Lead-Mining and Refining	Lime-stone slurries—14 mesh	....	....	....	....
	Portland Cement	Clay slurries up to 35% solids mesh varies	....	....	100	15
Inorganic & Organic Acid Solutions	Chemical	Dilute H_2SO_4 drainage	....	Atm	....	....
	Metallurgical and Ore Refining	Spent H_2SO_4 pickling liquor	....	90 F	....	....
	Leather Manufacturing	Tannic acid process and waste liquor	....	....	....	....
	Textile Manufacturing	Weak H_2SO_4 waste	....	....	....	....
Process waste liquors, and related	Chemical	Hydrofluoric acid waste	4-5	95 F Max.	10 Max.	....
	Chemical	Acetic acid all concentrations	....	....	....	....
	Pulp and Paper	Spent calcium bisulfite digesting liquor	4-5	100 F Max.	75 Max.	....
Gases, Vapors and Fumes	Chemical	Saturated steam	....	....	....	....
		Sulfuric acid fumes	....	....	....	....
		Steam exhaust with entrained HCl and $H_2C_2H_3O_2$	....	....	....	....
		Wet SO_2 with entrained abrasive solids—325 mesh	....	85 F	....	....
Brines, Salts, Bleaching Liquors and Miscel.	Chemical and Electro-Chemical	Sodium chloride up to 26%	....	Atm	....	....
		Ferric chloride to 40% with 1% HCl	2.5	150 F	....	....
		Sodium hypo-chlorite solution, less than 10%	....	Atm	....	....

a 22-inch Venturi throat. According to L. M. Leedom, construction engineer of the Newark Water Division, these wood lined Venturi tubes, which he described in a recent technical paper, were retired in 1949 after 58 years of uninterrupted, trouble-free service. Mr. Leedom epitomizes these structures as "marvels of workmanship and enduring monuments to the millwright's art of two centuries ago" and "a fine tribute, indeed, to the man who conceived the idea of wood linings and to the men who executed it." Coal mines, early in the century, made spasmodic attempts to line cast iron pipe with wood for acid water and abrasive waste service. However, difficulties associated with the accurate milling of staves and their secure placement in the iron pipe at the mine site delayed adoption of wood lined pipe in this industry.

While wood as an engineering material retains its recognized place elsewhere its use as a lining for steel pipe has not been as common as have other lining materials. However, wood linings for steel pipe and fittings have a successful performance record for 26 years in certain process industries, notably in pulp and paper manufacture—first to make extensive use of wood-lined steel pipe construction. A digest⁶ of experience with wood lined steel pipe is available for those interested.

Construction and Design

Kiln-dried, clear heartwood staves cut from Douglas fir, California redwood, Michigan pine, hard maple and sometimes cypress, or other species enter into the construction of the wood linings. These staves, before insertion into the steel pipe or fittings, are milled to accurate curvatures, to true radial planes and proper thicknesses and provided with a tongue along one lateral edge and a groove along the other to insure a wedge-tight, leak-proof joint. Figure 1, which pictures a fabricated mitered 90-degree elbow under construction, shows the stave design, relationship and final assembly.

The stave-ends of one mitre are joined to those of the next by means of plastic wood which, experience shows, provides not only a secure leak-proof joint, but a durable bond that often outlasts the staves themselves. The staves vary in length with that of the pipe-section, and range in thickness from $1\frac{1}{16}$ inch for 4-inch pipe to $1\frac{3}{8}$ inch for 30-inch pipe, while the steel pipe or fitting (flanged) varies

in wall thickness from 14 gauge (0.078-inch) through extra heavy wall (Schedule 80), depending upon the internal pressures and other mechanical demands.

The staves, driven into pipe by hydraulic ram and into fittings by pneumatic hammer, are inserted with wedge-like compression to exert a constant tension on the steel shell, which, as the wood lining swells with fluids, grows even greater, to bring about a desirable degree of pipe rigidity.

Little Corrosion at Interface

Virtual absence of corrosion failure at the wood-steel interface (dissimilar materials contact) observed over 26 years, strongly supports the belief that the staves are not fully penetrated by the fluid in the pipe despite pressures of 100-200 psi. Cross-sections cut from wood-lined steel pipes taken down for main-

tenance or alteration while in service, showed wetting of the staves hardly beyond mid-thickness on the average. This limited permeability is reconcilable with the fact, among others, that the heartwood of a tree trunk, in contrast to the open-cellwork of the younger, life-bearing sapwood, exhibits a consolidation of inactive cells grown dense with infiltrated materials.⁶ These infiltrations build up inside the cell cavities and cell walls as the sapwood matures into heartwood.

Considerable light is shed upon the extent and manner of water-transmission in wood staves by studies at the Laboratories of the Forest Products Division, United States Department of Commerce during 1937 and by German investigators ten years earlier.

The first of these investigations⁷ was carried out on cypress staves, old and new, subjected to water pressure of 65 psi for periods of one hour to one week, demonstrating that the water did not pass through to the other surface of the stave. The investigation also showed that water pressing against a stave surface in a pipe or tank did not travel radially; that the movement of water was longitudinal, starting from the point where the pressure was applied, through the given annual ring, to emerge at the cross-section. In staves where the grain ran parallel to the surface pressed upon, no water appeared at the cross-section. The study emphasized the fact that the transmission of water in a longitudinal direction observed in staves under water pressure, "is in entire accord with the behavior of the passage of liquids in tree-trunks" to quote the report. The German inquiry⁸ into water permeation was carried out on spruce staves varying in thickness from one inch to 1.5 inch—subjected to pressures from 100 psi to 180 psi for periods of 24 to 72 hours. The findings in this investigation parallel many of those of the Forest Products Division.

Species Adapted to Use

Species of wood are selected for pipe linings generally to be consistent with the application. Fir and redwood, for example, while used interchangeably in pulp-mill piping, differ enough in properties to warrant considered selection for certain classes of service. Pine, another example, serves best in exposure to acid mine waters, dilute mineral acids and stronger alkaline solutions, notably caustic soda—whereas a hard maple lining is best suited for slurries, or other abrasive suspensions like fly-ash, coal refuse, silica, clay, ground limestone, mine tailings, etc.

Temperature Limits

Temperature limit for wood, arbitrarily fixed at 180-185 F, is determined largely by the acidity, alkalinity and composition of the fluid carried in the pipe. For example, water, short of boiling, will have no adverse effect on wood; while a 5 percent solution

TABLE 2—Materials Suitably Handled by Wood Linings

Acids	Alkaline and Caustic Solutions	Salts	Aggressive Waters
Acetic Acid (all concentrations)	Calcium Hydroxide 3%	Aluminum Nitrate 20%	Fresh Water
Boric Acid (sat'd.)	Magnesium Hydroxide 25%	Alum 10%	Salt Water
Hydrochloric Acid (5% at 150° F.)	Sodium Bicarbonate 30%	Ammonium Sulfate 20%	Coagulated Water
Nitric Acid (5% at room temp.)	Sodium Carbonate 11%	Borax Liquor (dilute)	Acidified Water
Oleic Acid	Sodium Hydroxide 5%	Calcium Hypochlorite 1%	Acid Mine Water
Palmitic Acid	Sodium Silicate	Copper Sulfate 5%	De-mineralized Water
Phosphoric Acid 30%	Gases, Fumes and Vapors	Copper Nitrate 20%	Sea Water
Sulfuric Acid (5% at 140° F.)		Calcium Chloride 50%	River Water
Sulfurous Acid 15%	Sulfur Dioxide Carbon Dioxide Hydrochloric Acid Sulfuric Acid Hydrogen Sulfide Steam	Copper Cyanide 3%	Steam Condensate
Tannic Acid 10%		Ferric Chloride 25%	Miscellaneous
Tartaric Acid 30%		Ferrous Sulfate 3%	
		Mercuric Chloride 10%	
		Potassium Cyanide 2%	
		Sodium Chloride 25%	
		Sodium Chlorite 10%	Vegetable Oils
		Sodium Phosphate 3%	
		Sodium Perborate (sat'd.)	
		Sodium Ferricyanide	
		Sodium Hydrosulfite 4%	
		Magnesium Chloride 20%	Sour Crude Petroleum
		Magnesium Sulfate 20%	Septic Sewage
		Nickel Nitrate 20%	Abrasive Suspensions
		Nickel Sulfate 25%	
		Nickel Chloride 25%	
		Zinc Sulfate	

TABLE 3
Friction Losses in Pulp and Paper Stock Lines Using
Wood Lined Pipe
Head Loss in Feet/Hundred Feet of Pipe.
Stock Consistency 1%

GPM	Nominal Pipe Size (In Inches)				GPM	Nominal Pipe Size (In Inches)			
	6	8	10	12		6	8	10	12
200	...	...	...	...	2400	...	6.6	2.4	1.0
400	...	...	...	...	2600	...	...	2.7	1.2
600	2.0	...	...	...	2800	...	...	3.2	1.3
800	3.6	...	...	...	3000	...	...	3.7	1.5
1000	5.3	1.4	...	...	3200	...	...	4.2	1.8
1200	7.2	1.8	...	...	3400	...	...	4.6	2.0
1400	...	2.5	...	...	3600	...	...	5.0	2.2
1600	...	3.2	1.1	...	3800	...	...	5.4	2.4
1800	...	3.9	1.4	...	4000	...	...	5.9	2.7
2000	...	4.8	1.8	...	4200	...	...	...	3.0
2200	...	5.6	2.0	...	4400	...	...	...	3.2

of HCl or H₂SO₄ is detrimental to wood at temperatures above 150 F. To cite another example, a one percent solution of caustic soda, safely handled by most species at 125-135 F will not materially affect pine at boiling temperatures even up to 10 percent strength,⁹ nor cypress up to 25 percent concentrations.¹⁰ The range of allowable chemical exposure for wood, expressed in terms of pH, falls within 2.5 to 11.0, according to industrial experience. However, wood is not recommended for use with strong oxidizing agents, concentrated mineral acids and highly alkaline and caustic solutions.

Table 2 lists many specific materials¹¹ suitably handled by wood linings.

An advantage of wood-lined steel pipe construction of especial interest to corrosion engineers and others, is the combination of mechanical strength and corrosion resistance in a single structure. It has a demonstrated degree of corrosion and abrasion resistance. To the engineer concerned with hydraulic properties, wood-lined steel pipe often gives reduced friction losses with increased fluid flow compared to metals of equal predicted length of service.

The noted hydraulic and irrigation engineer, F. C. Scobey,¹² in his studies on the flow of water through wood stave pipe said "wood pipe will convey about 15 percent more water than a 10-year old cast iron pipe or a new riveted pipe and about 25 percent more

than a cast iron pipe 20 years old or a riveted pipe 10 years old."

Table 3 shows friction loss values,¹³ based on engineering statistics in pulp mills, for a one percent pulp suspension (99 percent water) carried in a wood-lined pipe.

Another advantage is the thermal insulating property of wood. This property is of particular importance where excessive heat losses, heat gains, or susceptibility to freezing becomes an economic or technical factor.

Resistance of Wood to Corrosives

Reproduced in Table 4 is S. J. Hauser and C. Bahlman's¹⁴ tabulation of their experimental results with six species of wood subjected to the action of 38

chemical agents embracing acids, bases, salts, organic substances and water for 30 days at room temperature and for eight hours at boiling temperatures. Reproduced with this table are the investigator's conclusions.¹⁵ The reader is referred to Hauser and Bahlman's original work¹⁶ for the full commentary.

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TABLE 4—Physical Effects of Chemicals Upon Wood¹⁴
After One Month in Cold and Eight Hours in Boiling Liquids

	Cypress		Fir		Pine		Redwood		Maple		Oak	
	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot
H ₂ O (Water)												
CH ₃ COOH (Acetic Acid)												
5% conc.												
25% conc.	SS		SS				SS					
50% conc.	SS		SS				SS					
glacial	SS		SS				SS					
HCl (Hydrochloric Acid)												
5% conc.							SS,VB	VS,B		SS		
10% conc.	SS	SS	SS		SS		SS,VB	VS,B				SS
25% conc.	SS,CL,SB	VS,VB	SS	VS,VB	SS		SS,VB	VS,VB,Ch	S,B	VS,VB	SS,SB	VS,VB
50% conc.	SS,CL,SB		SS		SS		S,B		S,B		S,B	
Conc. (a)	VS,B,Cl		VS,B,GR		VS,B,Cl		VS,VB		VS,B,Sh,Cl		VS,B,Di,Ex,Cl	
H ₂ SO ₄ (Sulphuric Acid)												
1% conc.	SS		SS				SS,B	VS		SS		W
5% conc.	SS		SS		SS		VS,B	VS,B			SS	
10% conc.	SS	VS,P	SS		SS		VS,B	VS,VB	SS,B		SS,SB	SS
25% conc.	SS,SB	VS,VB	S,B	VS,VB	SS	VS,VB	VS,VB	VS,VB,Ch	VS,VB	VS,VB	SS,B	VS,VB
HNO ₃ (Nitric Acid)												
5% conc.		S	SS	VS	S,Shd	VS,VB	VS,VB	VS,VB	SS	VS,Shd	SS,GR	S,CL,Shd
10% conc.		VS,Shd	VS,Shd	VS,Shd	SS	S,Shd	VS,VB	VS,VB,Cl,Shd	SS,SB	VS,Shd	S,B,GR,Sh	S,CL,Shd
25% conc.	S,B	Shd,VS	VS,B	VS,Shd	SS,B,Cl	S,Shd	VS,VB	VS,VB,Cl,Shd	S,B,Sh	VS,Shd	VS,VB,GR,Sh,Cl	S,CL,Shd
NaOH (Sodium Hydroxide)												
1% conc.		SS		Sh,GR			VS,W,SB,GR	S	Cl	Sh	Sh,Vh,Di	Vh,Sh,Di
5% conc.		SS		Sh,GR			VS,SB,GR	S	Sh	Sh	Sh,VH,Di,GR	Vh,Sh,Di
10% conc.		SS		Sh,GR			VS,GR,P	S,Sh,Di,GR	Sh,GR,W	Sh,GR,W	Sh,Vh,Di,GR,W,I	Vh,Sh,Di,GR
25% conc.	SS,P	SS	SS,GR,P	GR	SS	VH,Sh,Di,GR	SS,GR,P	S,Sh,Di,GR,B	Sh,GR,SS,P	W,G,R	SS,GR,W,P	WH,GR
Na ₂ S (Sodium Sulphide)												
5% conc.	SS		SS				S,P,B				SS,GR,P	
20% conc.	SS		SS				S,P,B				SS,GR,P	
NaHSO ₃ (Sodium Bisulphite)												
10% conc.							SS					
25% conc.							SS					
Na ₂ CO ₃ (Sodium Carbonate)				GR	GR							
5% conc.												Sh,GR
20% conc.		SS										Sh,GR
Ca(OH) ₂ (Calcium Hydroxide)												
10% susp	filtered						GR				GR	
Ca(ClO) ₂ (Bleaching Powder)							SS					
5% susp	SS,FZ,GR		SS,FZ,GR		FZ		S,GR,B,Sh,FZ		SS,FZ,Sh		GR,FZ	
10% susp	SS,FZ		SS,FZ		FZ		S,GR,B,Sh,FZ		SS,FZ		GR,FZ,SP	
NaCl (Sodium Chloride)				SS								
10% conc.							SS,SB		SS,SB			
25% conc.							SS,SB,GR		SS,SB			
CaCl ₂ (Calcium Chloride)												
10% conc.							SS					
25% conc.							SS					
Turpentine	SS		SS				SS					
Linseed Oil	SS		SS				SS					
Cottonseed Oil Fatty Acids			SS				SS					

(a) Effect of concentrated hydrochloric acid was recorded after only one week's exposure.

The physical condition of the test strips after one month in the cold liquids and after an eight-hour exposure to the hot fluids is shown in Table 4.

The following abbreviations were used:

- | | |
|----------------------|------------------------------------|
| SS—slightly soft. | Sh—noticeably shrunken. |
| S—soft. | Ex—noticeably expanded. |
| VS—very soft. | Cl—cracked lengthwise. |
| SB—slightly brittle. | W—warped. |
| B—brittle. | DI—considerably distorted. |
| VB—very brittle. | GR—grain raised or roughened. |
| P—pliable. | FZ—covered with downy "fuzz." |
| SP—slightly pliable. | CH—charred. |
| | Shd—shredded, easily picked apart. |

In Table 4 a dash indicates no noticeable action upon the wood, and, where the test was made at room temperature only, an unfilled space is left in the hot column. The results were recorded after the strips had dried in the air for one week after their removal from the liquids. There was very little difference in the condition of the wood just when removed from the liquid and after the additional air drying, except that in some cases a slight pliability in the wet wood

would disappear after drying, a slight brittleness being noted.

Table 4 reveals the action of the different chemicals upon each of the woods very clearly. Slight softness (SS) and a roughening of the grain (GR) probably have little significance and should not be taken as indicating unfitness of the wood. The other terms, however, are demerits which lessen the adaptability of the wood for use with chemical solutions.

Conclusions

a) Of all the chemicals used in these experiments, nitric acid and caustic soda are the most detrimental towards wood. The alkali and the stronger dilutions of nitric acid have a tendency to cause shrinkage, especially when heated.

b) There is always one wood (and often more) which is able to resist the action of the other chemicals, at least in moderate concentrations.

c) We can obtain a general idea of the relative fitness of the six woods from the number of instances in which each of them was detrimentally affected. Of the thirty-eight liquids used, the number which noticeably affected the different woods at room temperature (disregarding slight softness and roughening of grain) was as follows—pine 4, cypress 7, fir 8, maple 13, oak 15, redwood 22.

advertising counsellors of Bay City and to Dr. Malvern J. Hiler, president of The Commonwealth Engineering Company of Ohio, Dayton, for their critical review of the manuscript.

References

1. Columbia Encyclopedia, Columbia University Press, 2nd Edition, 1950. Page 1550.
2. Wood Handbook, U. S. Dept. of Agriculture, Forest Products Laboratory. June 1, 1940 Edition, Page 20.
3. *Ibid*, Page 28.
4. Laurie M. Leedom. Two Old Veterans Retired by Newark, Water & Sewage Works. February, 1952. Pages 63-67.
5. Service Experience Files: Engineering Dept., Michigan Pipe Company, Bay City, Mich.
6. Wood Handbook. U. S. Dept. Agriculture, Forest Products Division. June 1, 1940 Edition, Page 13.
7. Forest Products Division, Dept. of Commerce. Resistance of Wood to Chemicals. October 1937 Edition, Page 15.
8. Dr. H. Seitz, Wasserdichtheit Von Fichtenholz (Impermeability of Spruce). Die Bautechnik 1929, Heft 48.
9. Forest Products Division, Dept. of Commerce. Resistance of Wood to Chemicals. October 1937 Edition, Page 13.
10. *Ibid*, Page 13.
11. Michigan Pipe Company, Engineering Bulletin 0-050, January 20, 1950 Edition.
12. Fred C. Scobey. Flow of Water in Wood Stave Pipe. U. S. Dept. Agriculture, Bulletin No. 376, 1926 Edition, Page 73.
13. Michigan Pipe Company, Engineering Bulletin No. 325-140.

14. Forest Products Division, Dept. of Commerce. Resistance of Wood to Chemicals, October 1937 Edition, Page 14. Also courtesy of The Hauser-Stander Tank Co., Cincinnati, Ohio.
15. *Ibid*, Page 13.
16. S. J. Hauser & Clarence Bahlman. A Study of the Action of Various Chemicals Upon Different Woods Used for Chemical Tanks. Courtesy of Hauser-Stander Tank Co., Cincinnati, Ohio.

Bibliography

- Steg Regnel. Wood Stave Pipes, Bulletin No. 23, Institution of Hydraulics, Stockholm, Sweden. Transactions of the Royal Institute of Technology.
- S. C. Chaney. Wood Vs. Corrosion. *Corrosion and Mat. Prot.*, January-February 1947 Issue, Pages 6-11.
- C. S. Robinson. Wood as a Chemical Engineering Material. *J. of Ind. & Eng. Chem.* July, 1922 Issue.
- Arthur Koehler. Properties & Uses of Wood. Forest Products Laboratory, Madison, Wisconsin.
- D. C. Picard. Report on Tests on Certain Wood Species Resistant to Acids. Chemical Engineering Laboratory, Birmingham, Alabama.
- F. N. Speller. Corrosion, Causes & Prevention, 1935 Edition, McGraw-Hill Book Co.
- E. Rabald. Corrosion Guide, 1951 Edition. Elsevier Publishing Co., N. Y.
- California Redwood Assn., San Francisco, Calif. Redwood Tanks for Chemical Solutions.
- California Redwood Assn., Bulletin on Redwood Pipe, Sect. III, File 3 DX, Sheet 2-11-51.
- Corrosion Handbook, 1948 Edition. The Electrochemical Society, Inc., N. Y.

Coating Pipelines In Place Internally With Plastics*

By J. C. WATTS

Introduction

INTERNAL CORROSION of gravity and low pressure or intermittently operated discharge lines in sour crude service is a serious problem. Several means of protection have been tested, but no one method has proved to be a "cure all." Among the more promising tools is internal plastic coating.

Investigation of internal plastic coating of pipe began as early as 1940 with the baked phenolics, the only materials available at that time. This material has been used widely for drill pipe, fittings and where the use of mechanically coupled pipe was practical. Its use in the pipe line industry has been limited because welding damages the coating at the joints.

The development of the air drying vinyls widened the use of plastic coatings. However, these still did not provide a practical means of protecting pipe lines already in place.

The need for protection of the many miles of pipe lines already in the ground brought about the development of a method of internally coating of pipe lines in place. This method was first attempted in 1947, the first oil line to be internally plastic coated in place was a 4-inch gathering line in the Means Field. This line was coated in April, 1948 using one prime coat and one top coat of a conventional vinyl coating.

Cleaning Methods

General acceptance of in-place coating application has been hindered by the lack of adequate cleaning techniques more than any one factor. It has been a basic principle of plastic coating application to have an exceptionally clean surface with a good anchor pattern for mechanical attachment of the paint film. For most applications, blast cleaning and pickling are generally considered the only acceptable methods of surface preparation.

Despite the difficulties of cleaning a badly corroded gathering line in place, the use of petroleum solvents and wire brushes, along with other cutters and abrasives has provided amazingly good surface preparation. However, it does not approach the standards considered necessary for plastic coatings in other applications. This method does not remove the final film of corrosion products or neutralize the corrosive action of sulfide products which remain in minute cracks in the metal surface, nor does it provide the anchor pattern considered necessary for good coating adhesion.

Inspection of lines coated during the early stages

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Abstract

Since 1947 various materials including baked phenolics, air drying vinyls, thermosetting polyesters, furanes and others have been used with varying success for the internal coating in place of pipe lines. Development of high-solids vinyls and amine cured Epoxies has made the process more dependable.

Principal problem in applying the coatings is in surface preparation. The author recommends a scheme involving successive cleaning by abrasion, solvent cleaning, alkaline cleaning and acid cleaning with the necessary intermediate washings. Drying is effected best by aspiration until the coating is thoroughly dry. "Solvent washing" resulting from the condensation of solvent at cool places in the pipe is a primary difficulty in the drying process. Tests of drying times are reported.

Considerable data on economics of internal coating on about 100,000 feet of pipe are given, indicating payout for some types of service in short lines in as short a time as one year. Economics of internal plastic coating are not as good for long lines as for short ones. Several case histories of lining economics are given.

Collateral benefits in improved flow capacity and reduction of paraffin deposits are reported.

Factors to be considered when planning an internal coating job are given.

of the development of this process has generally exhibited poorer coating adhesion than is considered necessary for other coating applications. Nevertheless, these coatings have remained in good condition year after year and have continued to provide leak free and, insofar as can be determined, corrosion free service. It may be presumed that surface preparation is not as critical in this application as in others. However, the full value of the available coating materials could be utilized better if better surface preparation could be secured.

At present there is no standard cleaning procedure, various contractors having their own methods.

Surface Contaminants

In general to insure maximum coating life there are three types of surface contaminants which must

be removed before applying coatings. The completeness with which each of these is removed will materially affect the service life of the coating. These three types of contaminants include:

1. Grease, oil, dust, etc.
2. Scale
3. Visible and invisible corrosion stimulators

Cleaning Methods

Three cleaning procedures in addition to abrasive action can be used to remove these contaminants from a pipe line.

Each will remove certain products. Elimination of any one of the three will leave either an undesirable film on the surface or make the next step more difficult. The three cleaning methods are:

1. Solvent cleaning
2. Alkaline cleaning
3. Acid cleaning

Solvent cleaning is the least effective of the three. Where possible, it should be used only to supplement the other two. It is effective in removing most of the oil and paraffin accumulations in the line. However, most petroleum solvents themselves leave a slight oily film on the pipe wall which must be removed.

Alkaline cleaners are more efficient, cheaper and less hazardous than solvent cleaners. Deposits are removed by saponification and detergent action rather than by solution. After the deposits have been displaced, they are emulsified throughout the body of the cleaner and removed from the line. In order to perform all these actions the solution should contain wetting agents, detergents, emulsifying agents and saponifying agents. Because heat enhances the activity of the alkaline cleaner, this type of solution is not as effective when used cold, as is necessary in this operation. However, it will prepare the surface for acid cleaning and will remove traces of oil and grease left by the petroleum solvent. The use of an alkaline cleaner will minimize the danger of an explosion by leaving a gas-free line. Alkaline cleaners must be followed by an acid solution because the coating will not bond to an alkaline surface.

Acid solutions for surface preparation prior to coating have been tested thoroughly by years of experience. In addition to the acid constituents, oil solvents such as alcohols, or ketones, detergents and wetting agents to assist in wetting the surface and removing the contaminants and an inhibitor to prevent excessive attack on the metal to be cleaned are required. Acid cleaners effectively remove light rust and scale and remove or neutralize invisible corrosion stimulators. The acid solution also will etch the metal surface, improving coating adhesion. An insoluble iron phosphate film is formed by the reaction of phosphoric acid in the cleaner and the metal surface. This film offers a good base for the coating and also retards underfilm corrosion at discontinuities in the coating film and at points where the coating is damaged.

Chemicals were first used to clean a pipe line in place in 1951. These first jobs were not successful because the solutions used were designed to be used

hot and also required a longer contact time between the solution and the metal than is possible in this operation. Alkaline cleaners which were only slightly soluble at atmospheric temperature were used. Failure to neutralize the pipe with an acid rinse left a film on the surface which was difficult to remove by a water rinse.

In the spring of 1953 an acid cleaner containing a mixture of acids including inhibited hydrochloric and phosphoric acids was developed especially for this type service. Also, in the solution are a solvent and a wetting agent. Before the acid solution is effective, the heavy oil and grease deposits and the heavy scale must be removed by abrasive action and by solvent and alkaline cleaning. The acid cleaner will remove the remaining corrosion products and leave a clean acid etched surface which has the appearance of having been sandblasted. Some difficulty has been experienced due to the atmospheric rusting of the pipe wall during the water rinse. Using an inhibitor in the wash water shows promise of eliminating this problem. The cleaning method is chosen largely on the basis of economics. Although chemical cleaning may be superior to other methods, in some cases it may increase the cost of cleaning a line more than is warranted for the little improvement in surface preparation. In other cases chemical cleaning may decrease the time needed to clean the line enough to cause a savings in cleaning costs.

Coating Materials

One of the major problems in the development of the in-place application was finding a suitable coating. In the early days of development conventional vinyl formulations were used but it was difficult to get a symmetrical coating because these materials have a tendency to run and sag. The conventional formulations also were susceptible to "solvent washing."

Thermosetting Polyesters

A catalytic accelerated thermosetting polyester resin having 100 percent solids was the first special formulation to be tried. The accelerator was added immediately prior to application of the coating. This coating was applied to several lines with varying degrees of success. Because the amount of accelerator required was very critical, the application was too uncertain for field use. Small changes in temperature changed the setting time considerably. After setting up, the coating was very brittle and had practically no bond to the pipe. Indications were that this material served more as a liner than a coating. After a few jobs the use of this material was discontinued.

Furane Materials

The next material to be tried was a furane based material. Due to its high solids content, this coating has good resistance to "solvent washing" and good flowing and anti-sagging qualities. Because no plasticizers are necessary in its formulation, it does not lose its flexibility due to leaching of the plasticizer. High cost has prevented widespread use of this material.

High Solids Vinyl

After approximately three years' development, high solids vinyls have been offered for this application.

It is well suited to the in-place application, has a very high solids content and is fast drying, a factor which reduces the danger of "solvent washing." Figure 1 shows a sample cut from a 4-inch line approximately 9700 feet long coated with this material.

Epoxy-Based Material

The most recent materials which show promise for this application are the amine cured epoxy base coatings. Although these materials have excellent adhesion and are easily applied they have not been in service long enough for complete evaluation. Figure 2 shows a sample cut from a 4-inch line approximately 2700 feet long which was coated with this material.

Many paint films applied in one coat have a high degree of porosity due to bubbles formed by escaping solvent or water of polymerization and entrapped air in the coating material. Overcoating with a second coat reduces pinholes. For maximum coating performance coating thickness should exceed 5 mils and application in two coats may be recommended for some materials.

Coating Application

Because the techniques involved in the coating operation have been thoroughly covered in previous papers, only a brief summary will be given here. A very complete description of the process was given in M. B. Groves' paper "Internal Coating of Pipe Line in Place."¹

In general, all contractors doing this work use the same method of coating application, differing mainly in the type and number of plugs and in their cleaning methods. The principal of forcing the cleaning or painting plugs through the line by compressed air is used by all contractors. The plugs are introduced into and removed from the line through specially designed loading joints. These joints have provision for valves through which the cleaning solutions and coating materials are injected into the line.

A typical coating job would probably follow the following procedure: The oil in the line is first displaced with water or displaced directly by several batches of a petroleum solvent followed by individual batches of an alkaline degreasing solution. Each batch will be separated with rubber plugs. The latter method is believed to provide a gas free line safe from explosive hazards and will also provide the initial cleaning.

The line is then cleaned by sending batches of either a petroleum solvent or a chemical degreasing solution through the line by means of rubber plugs. Abrasive action is obtained either by use of wire brushes or steel lathe cuttings. At least one contractor uses an acid solution for the final cleaning. If acid is used, the line is rinsed with water and rubber plugs are run to remove the excess water. The remaining water and any grease which may remain is removed



Figure 1—High solids vinyl coating applied to a 4-inch pipe by the in-place method.

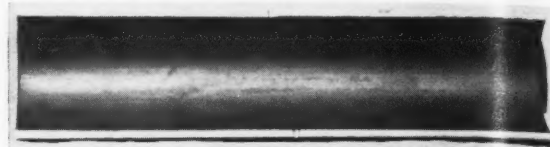


Figure 2—Epoxy coating applied to 4-inch pipe by the in-place method.

by running a batch of methyl ethyl ketone. The line is dried with air until the internal surface is dry. The line is then inspected and if clean the coating application is begun.

The prime coat is applied either by placing the primer in front of a rubber plug which is pushed through the line at a high speed, or by inserting the primer between two counterfacing paint plugs and carrying it through the line against a constant back pressure. Both methods seem to give equally good results. Excess primer is removed at the downstream end and the deposited coating air dried. The finish coats are applied in the same manner as the primer. Following the last finish coat, the line is dried for several hours and then returned to service.

Drying Procedures

"Solvent washing" of the applied coating has been the limiting factor in determining the length of line that can be coated in one operation. Drying air moving through the pipe picks up solvent vapors from the plastic film, the concentration continuously increasing as it goes through the pipe. At the point where the air becomes saturated with solvent, the plastic film is washed off the pipe by the condensing vapors. Solvent washing of the applied coating appears to occur when the air is moving too slowly or through too long a length of line. Solvent washing also has occurred at points where the pipe was exposed and was colder than the pipe underground. This condition apparently causes condensation of the solvent on the colder surface.

Solvent Increases in Stagnant Air

If the movement of air through the line is stopped before the coating is dry, the solvent concentration will build up in the stagnant air inside the pipe and condensation may occur. Even though the coating appears to be completely dry and probably would be

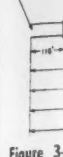


Figure 3

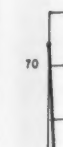


Figure 4



Figure 5



Figure 6



Figure 7



Figure 8



Figure 9



Figure 10



Figure 11



Figure 12



Figure 13



Figure 14



Figure 15



Figure 16



Figure 17



Figure 18



Figure 19



Figure 20



Figure 21



Figure 22



Figure 23



Figure 24



Figure 25



Figure 26



Figure 27



Figure 28



Figure 29



Figure 30



Figure 31



Figure 32



Figure 33



Figure 34



Figure 35

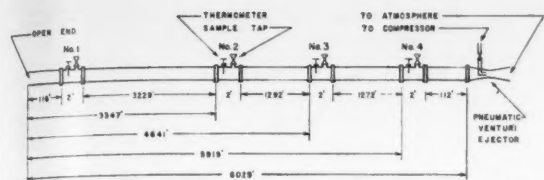


Figure 3—Schematic diagram showing test locations used in drying tests on 3-inch line.

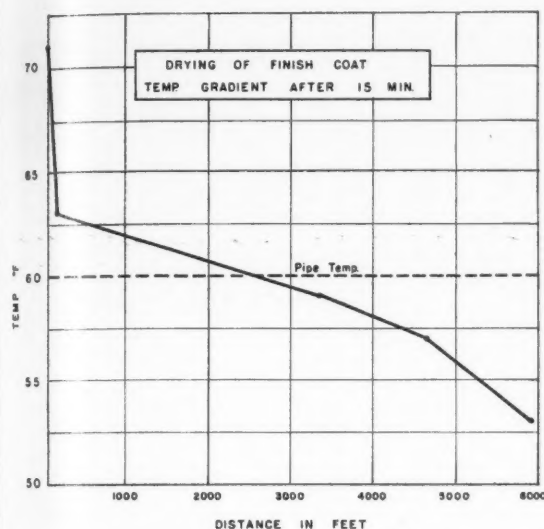


Figure 4

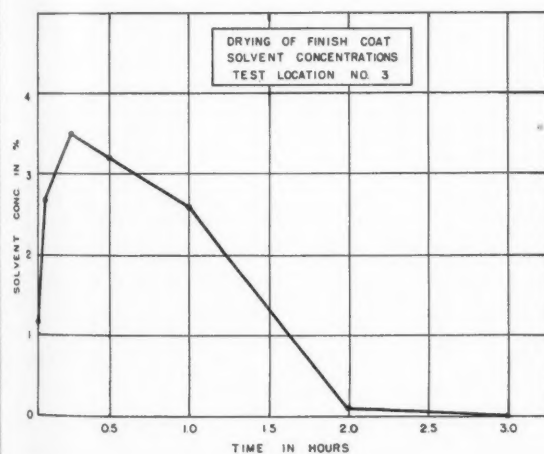


Figure 5

the pressure aids the escape of the solvent from the wet film and reduces the possibility of pockets of solvent being trapped after the wet coating has filmed over. The trapped solvent eventually will diffuse through the coating but will leave a void. Contamination of the wet coating by moisture condensation on the pipe wall and by oil thrown by the compressor is possible when compressed air is used.

Tests of Drying Rate Made

In order to establish drying procedures which will minimize the danger of solvent washing, a series of tests were made to determine the rate of drying of a coating under actual field conditions. The data were collected during the coating of a 3-inch line approximately 6000 feet long. A vinyl formulation containing 48 percent solvent was used. Taps were placed in the line to allow insertion of thermometers and for withdrawing samples of the pipe atmosphere. Figure 3 shows the location of these taps.

Drying was accomplished by aspirating air through the line at a velocity of 155 feet per minute. A vacuum of 1.2 inches of mercury was pulled by the aspirator. Data was collected at various intervals over a three-hour period. Figure 4 is a plot of the temperature gradient after 15 minutes. Solvent evaporation caused the temperature to drop suddenly in the first 100 feet and continue to drop throughout the length of the line. As the drying progressed, the temperature gradually increased until it approached the original pipe temperature.

Figure 5 shows the change in solvent concentration with time. This data was collected at test point No. 3. The solvent concentration increased to a maximum of 3.5 percent after 15 minutes and then gradually dropped until after two hours only 0.2 percent was found. Although after three hours the tests showed no solvent present and the coating appeared dry, the coating solvent washed overnight. Similar curves plotted for all locations gave the same picture. No similar tests have been run while drying under pressure, nor are data available for lines of other sizes and lengths.

Performance

Humble Pipe Line has approximately 225,000 feet of pipe in its West Texas gathering system which has been internally plastic coated in place. This represents 3.8 percent of total pipe in the system. Lines which were coated had experienced 253 leaks from 1945 to the time of treatment. With the exception of two lines in which a satisfactory coating was not applied, there have been no leaks due to internal corrosion in the coated lines.

A look at the history of the lines in the Fuhrman-Mascho Field (Figure 6) will give a good indication of the effectiveness of plastic coatings because most of the internal protection in this area is by plastic coatings.

The first coating in this field was applied in 1948, since when approximately 100,000 feet have been coated, representing 20 percent of the pipe in the field. The leak frequency in the field has dropped from 0.69 leaks per mile in 1948 to 0.07 in 1953. This

considered dry on a surface exposed to the air movement, there often is enough solvent left in the coating which will continue to evaporate and cause "solvent washing" in the confined pipe atmosphere.

Aspiration Appears to Be Better

There is evidence that better results are obtained by aspirating air at atmospheric temperature and reduced pressures through the line than when warm compressor air is blown through the line. Reducing

decline has been in spite of the fact that the facilities are getting older and leaks are developing in lines that have had no previous failures.

Economics

The coating in lines handling corrosive crude normally will pay for itself in about a year through savings in leak repairs and oil loss. Taking into consideration the loss in investment and cost of major repairs will decrease the payout time.

As an example, the estimated maintenance cost of three lines for the year prior to applying the coating is given in Table 1. These figures are based on \$75 per leak for repairs and the value of the oil at \$2.61 per barrel.

One of these lines, which consists of 2950 feet of 4-inch pipe, had six leaks in the year prior to coating, with an oil loss of 245 barrels. The estimated cost of these leaks, including the value of the oil was \$1090. The line was internally coated in place for \$855.

Another line, consisting of 7380 feet of 4-inch, had 21 leaks in the year prior to coating, with 737 barrels of oil lost. The estimated maintenance cost, including cost of leak repairs and the value of the oil lost, was \$3500. This line was internally coated in place for \$2140.

Longer lines will not pay out as fast because the cost of corrosion when expressed on a per foot basis will not be as high. This will be true even though the total cost of corrosion is much greater. The price per foot for coating will be practically the same.

One of Humble's lines consists of approximately nine miles of 6-inch pipe. This line had 22 leaks with an oil loss of 925 barrels in the year prior to coating. The estimated maintenance cost for this period was \$4065. The cost of internally coating this line was \$20,400, which indicates a payout in approximately five years.

Although the internal coating of pipelines in place has proved to be effective in protecting pipe lines against internal corrosion before a decision is made to coat a line the economics of other means of protection should be investigated. Each line usually represents an entirely different problem, so no set formula can be given for general use.

L. G. Sharpe in his paper on "Economic Considerations in Pipe Line Corrosion Control"² covered this for a new line at the time of laying. This analysis did not take into account the many miles of pipe already in the ground. Assuming that a decision on a means of protecting two lines of those detailed in Table 1 is needed, the figures available indicate that plastic coating will pay out in less than a year on the Skelly-W. T. Ford line and in approximately five years on the Mascho 6-inch line. Although there are other means of protection available in order to save time, consider only concrete lining and the use of inhibitors as alternatives to plastic coating. The service life of a plastic coating is unknown because the oldest coating has been in service for only a little over eight years. However, a conservative estimate is that 10 years' service can be expected.

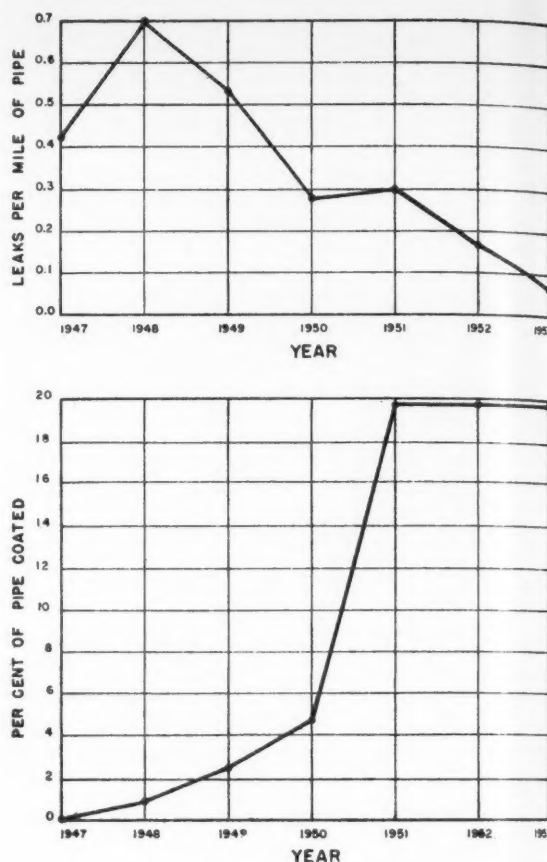


Figure 6

TABLE 1
Comparison of Maintenance Cost for Year Prior to Coating and Cost of Coating Four Lines in Fuhrman-Mascho Field

LINE	No. of Leaks	Bbls. of Oil Lost	Est. Cash Loss Oil & Leak Repairs	Length	Cost of Internal Plastic Coating
Gulf-W.T. Ford Batt. No. 1	6	245	\$1090	2968	\$ 860.00
Skelly-W. T. Ford 4-inch Discharge	21	737	3500	7380	2,140.00
Shell-E. F. King 4-inch Gravity Line	6	113	745	2610	757.00
Mascho 6-inch Discharge	22	925	4065	45400	20,430.00

Plastic Coatings Most Economical

Costs of the three means of protection are summarized in Table 2. This comparison indicates that plastic coatings are the most economical method of protecting lines which are already in service under 4 to 5 miles, while inhibitors show the best payout for longer lines.

However, many times other factors will enter the picture to change this relationship. Inhibitors usually are cheaper for long lines because the amount of inhibitor required varies more with the quantity of oil moved than the amount of steel to be protected. Cement linings are economically favored when the line is being laid but are not practical as a maintenance because the cost of dismantling the present line and laying the new cement lined pipe must be

TABLE 2
Comparison of Cost of Various Methods
Of Internal Corrosion Control of Existing Lines

Type of Protection	Cost of Protection (Ft./Yr.)	
	Skelly-Ford 4-Inch	Mascho 6-Inch
Plastic Coating ¹	\$0.030	\$0.045
Cement Lining ²	0.100	0.132
Inhibitor	0.117	0.020
Maintenance Cost ³	0.620	0.824

¹ Assuming 10-year coating life.

² Pipe dismantled and replaced with second-class cement lined pipe.

³ Actual average 10-year maintenance cost including all major reconconditioning.

TABLE 3
Flow Tests of 4-inch Fire Line After Internal Coating

Distance of Hydrant from Pump in Feet	Residual Pressure at Hydrants	
	Calculated Pressure in psi	Actual Pressure in psi
1950	51	70
1725	60	74
1575	65	76
1350	74	86
1175	84	92

considered. All methods of protection, however, show a good payout compared to the maintenance cost of an unprotected line.

Increased Capacity

In addition to providing protection of the pipe interior from corrosion, indications are that line capacity can be increased substantially by internal coatings. There is no record of tests run on lines handling oil or gas but there is some information on water lines which have been coated internally. Table 3 shows the results of such a test which was made by the Cabot Carbon Company following the coating of a fire line at their Hobbs, New Mexico, plant. A 1½-inch nozzle was attached to the fire hydrant located the farthest from the fire pump, a distance of approximately 1950 feet. With the nozzle open and 125 lb. pressure at the fire pump, the flow meter showed that the pump was delivering 290 gallons per minute. On the previous test made before the line was coated, only 190 gallons per minute could be obtained under the same conditions. Table 3 shows the pressure readings obtained at hydrants at various distances from the pump as compared to the calculated pressures. The calculated pressures are based on the normal drop through new 4-inch pipe delivering 290 gallons per minute, which is 3.78 lb. per hundred feet.

A portion of the increased throughput was probably due to the removal of scale and tubercles. However, after coating the line will maintain original flow because no further scale will collect. Reduced pressures are true indications of the effect of the coating because the pressures given are calculated using criteria for new pipe.

Paraffin Resistance

Plastic coatings also are being used successfully for paraffin control in oil well tubing and flow lines. Several companies have reported that flow lines which had to be steamed every few weeks to remove paraffin

have remained clean since the coating was applied—in some cases over four years ago.

A flow line in the Permian Basin of West Texas which had to be steamed every thirty days was chosen to test the effectiveness of plastic coatings in paraffin control. One-half of the line was coated and the line returned to service. After six months it was parted for inspection. The uncoated section had a paraffin build-up reducing the effective inside diameter of the pipe to less than half the original diameter. The coated section was clean and free from paraffin. In some cases when new installations are made, substantial savings have been made by using smaller diameter flow lines than would be necessary if the lines had not been internally plastic coated.

Summary

Although the internal coating of pipe lines in place originally was developed to provide protection to oil lines carrying sour crudes, this process is now being used successfully in other fields. Approximately two million feet of pipe of all sizes have been coated in the last six years by various contractors. Lines in water, gas, gasoline and butane service are now being protected from internal corrosion in this manner. Recently this process has been used to coat lines in chemical plants.

Because of the variation of the cleaning and coating application used by the individual contractors, no precise specifications or set procedures can be established at this stage in the art of internal cleaning and coating of lines in place. Users must choose the contractor whose practices best meet their requirements because each contractor offers and usually insists on following his own procedures. Following are some of the factors which should be considered before a job is attempted:

1. A responsible company representative should be assigned as inspector.
2. Sufficient inspection points should be provided and each operation should be inspected before moving to the next.
3. The pipe should be cleaned by the most effective method available. The most promising at present is the use of multiple batches of cleaning, degreasing and pickling solutions to supplement mechanical abrasion by brushes and steel cuttings.
4. Before full scale use of a coating is made it should be tested under field conditions. One of the major causes of failure in internal coatings is the checking and cracking of coatings. This is caused by the coating being too brittle to withstand the contraction and expansion of the pipe. Testing the coating on a small scale under static conditions will not determine the resistance of the coating to this condition. The coating also should be resistant to solvent washing and sagging.
5. A multiple coat system should be used to assure complete coverage and a minimum of pinholes. Two top coats with 5 mils film thickness is usually considered the minimum for a satisfactory coating.
6. Coating should not be applied when the atmospheric temperature is below 40 degrees F or when the dew point approaches the atmospheric temperature.
7. The manufacturer's recommendation on drying should be followed. The preferred method is by aspirating air through the line under reduced pressure.
8. Exposed portions of the line should be covered to prevent differences in temperature of the exposed and buried pipe.
9. The coating should be completely dry before the forced movement of air is stopped.
10. Safety rules should be established to avoid possible explosions and possible injury to personnel and property due to the force of escaping plugs and cleaning materials.

The art of internally plastic coating pipe lines in place has come a long way in the last six years, but it still is an art. Before the process can be considered equal to other coating applications, the scientific principles involved need to be more thoroughly investigated. In too many cases trial and error methods have been used to overcome difficulties that have arisen. This procedure does not locate the real problem. If proper engineering analyses of these situations are made, it will be possible to predict when they will happen and prevent their recurrence. In addition to further work needed in development of coating materials and cleaning techniques, further development of the coating plug design to provide closer control of the coating thickness is needed.

A Technical Note

Strong Earth Currents Complicate Surface Potential Measurements*

By DAVID HENDRICKSON*

STRONG earth currents which complicated surface potential measurements and which after a time reversed the direction of flow were encountered on a section of pipe maintained by the East Bay Municipal Utility District in the vicinity of Oakland, California.

The phenomenon was noticed in making tests on a pipe line. High potential readings were obtained at a test location on the pipe line five miles from the nearest cathodic station. Surface earth currents flowing by the pipe line indicated current discharging on one side of the pipe. The same indications were obtained when test holes were drilled to pipe depth. But when the near electrode was placed within an inch or two of the pipe, the potential readings indicated current pick up and evidenced satisfactory protection for the pipe.

Further checking was done on surface potentials near the anode beds of several cathodic stations where some of the current was flowing by the pipe line. Surface potentials readings taken at two different points, both some distance from the pipe, indicated current discharge. Two underground points, both also at a distance from the pipe gave similar readings. But when an electrode placed about two inches from the pipe was connected to the distant

Despite these shortcomings, it is impossible to refute the fact that tremendous savings have been made through the use of this process. Indications are that a more scientific approach is being taken by the present contractors. The coating manufacturers are also taking a much greater interest in providing the contractors with coatings specially adapted to this application. Possibly in the near future the in-place coating application will become a science.

References

1. M. B. Grove. Internal Coating of Pipe in Place. *Corrosion*, 10, 142-146 (1954) May.
2. L. G. Sharpe. Economic Considerations in Pipe Line Corrosion Control. *Corrosion*, 11, No. 5, 227t-240t (1955) May.

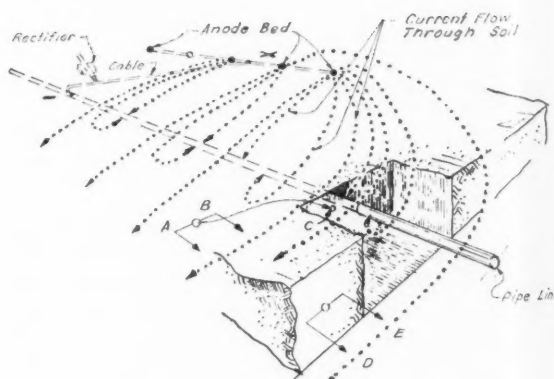


Figure 1

surface point, the instrument indicated current pickup and adequate pipe protection.

Before all tests on the pipe line had been completed, the earth currents had reversed direction. Reversal of earth currents have been observed in the past during irrigation season by corrosion engineers of the Pacific Gas and Electric Co., Berkeley, Cal., Bureau of Tests and Inspections.

Results of the investigations indicate it may be necessary to make some modifications of the surface potential method of testing for adequate pipe protection.

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Laboratory Development of Corrosion Inhibitors*

By LOYD W. JONES and JACK P. BARRETT

Introduction

DURING an investigation of corrosion caused by the presence of both hydrogen sulfide and oxygen in oil field brines, it was discovered that most inhibitors are totally ineffective or give only erratic protection. Compounds capable of inhibiting steel exposed to air-free hydrogen sulfide and others known as oxygen or rust inhibitors were tested. The failure of these materials provided the impetus to develop a new compound which would be effective under such severe conditions.

From the original material developed in the laboratory, a new series of inhibitors was formulated. Each modification was successively screened and field tested before the formula was adopted.

A review of the history of the compounds is presented here to illustrate some of the fundamental procedures of laboratory development work, starting with a specific problem.

The Problem

During the primary production of oil and gas, oxygen does not ordinarily have the opportunity to mix with well fluids to any appreciable extent. Cases have been found, however, where very serious corrosion has resulted from air gaining entrance into the open casings of oil wells producing sour (hydrogen sulfide containing) crude.

The possible role of oxygen in the subsurface corrosion of sour wells has been previously discussed by Prange¹ and others. Traces of oxygen can greatly increase hydrogen sulfide corrosion² and the combined effect of the two agents is most pronounced at proportions of about 99 percent air and 1 percent hydrogen sulfide.³ The extremely rapid corrosion resulting from high concentrations of both hydrogen sulfide and air can be readily observed in crude oil storage tanks.

Practically all ratios of air to hydrogen sulfide can be reached in producing equipment when air is used as lift gas or to repressure formations producing sour crude. An inhibitor capable of retarding this type of attack could remove one of the major objections to the use of air for such operations. To find such an inhibitor was the original purpose of this investigation.

Test Procedure

Before any selection of inhibitor materials could be made, it was necessary to devise a test procedure in the laboratory to simulate the corrosion problem. The basic feature of the test was exposure of steel specimens to brine containing oxygen and hydrogen sulfide. First, a series of one liter glass bottles was placed in series on a shaking device. The bottles were fitted with inlet and outlet tubes so that a gas stream



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Abstract

The procedures used by a major oil company laboratory to develop a new series of corrosion inhibitors are presented. Initially developed to inhibit corrosion caused by combinations of air and hydrogen sulfide, the base chemical was found to be effective in laboratory tests with most other corrosive agents encountered in the oil producing industry. Several modifications of the base compound were made and have proven successful in the field. A review of the history of these inhibitors illustrates a pattern of development work which started by finding a material to solve a specific problem and expanded the solution to related problems.

could be passed through each container in succession. A gas mixture of 99 percent air and 1 percent hydrogen sulfide was used. Additions of 800 milliliters of 5 percent sodium chloride brine and 16 milliliters of kerosene were made to each bottle.

1 x 1 x 1/16-inch mild steel test panels were mounted on brass rods with insulating washers and one was suspended in each bottle from a rubber stopper. The whole assembly is shown schematically in Figure 1. Each component of the gas mixture was metered into a mixing tube by means of finger pumps operated by a variable speed motor. The flow rate was high enough that no measurable depletion of either H₂S or O₂ occurred after the brine in each container was saturated.

To make a test run, the bottles were filled and fitted with stoppers holding the test panels, then mounted in the shaker and the gas stream started. The shaker was controlled with an automatic timer to provide 15 consecutive minutes of violent agitation at the start of the test and at two-hour intervals

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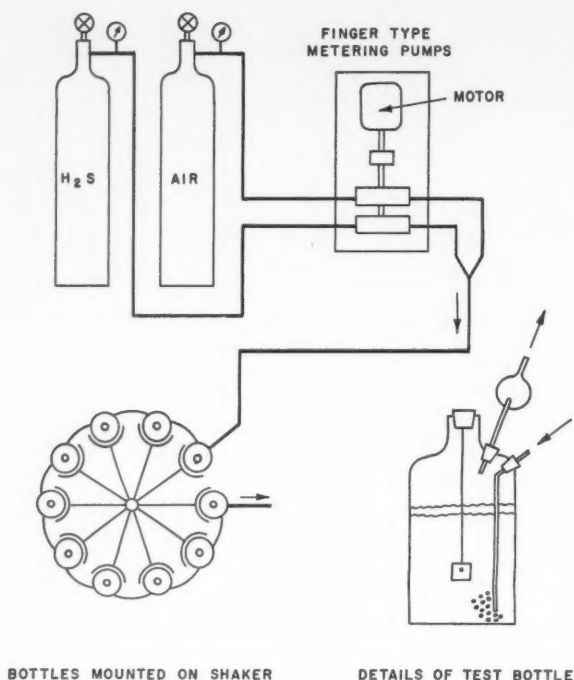


Figure 1—Corrosion test apparatus.

COMPOUND	RESULTS
$ \begin{array}{c} \text{N} - \text{CH}_2 \\ \quad \\ \text{R} - \text{C} \quad \text{CH}_2 \\ \\ \text{R}' \end{array} $	UP TO 50% INHIBITION BUT ALLOWED SEVERE LOCAL CORROSION
$ \begin{array}{c} \text{CH}_3 \quad \text{CH}_2\text{N} - (\text{CH}_2\text{CH}_2\text{O})_x \text{H} \\ | \quad | \\ \text{C} \quad \text{C} \\ | \quad | \\ \text{CH}_3 \quad \text{CH}_3 \end{array} $	UP TO 50% INHIBITION BUT ALLOWED SEVERE LOCAL CORROSION
$ \text{RCOONa} \\ \text{(METAL SOAP)} $	ALLOWED SEVERE LOCAL ATTACK

Figure 2—Typical results with available inhibitors.

thereafter. Shaking was desired to allow the oil phase, in which oil soluble inhibitors were dissolved, to contact the test panels. However, it was advantageous to keep the panels in the water phase most of the time to produce severe corrosion within a few days. Exposure time was seven days for most tests. Temperature was held at 100 F by placing the entire assembly in a constant temperature box.

Before the tests were started, the panels were polished on a metallurgical sander, cleaned with detergent, given a slight acid etch, dried and weighed to 0.1 milligram. After exposure, the panels were cleaned of corrosion products with inhibited hydrochloric acid followed by scrubbing with detergent and a mild abrasive. It was found that uninhibited test panels would lose up to 36 percent of their weight in a seven-day test and exhibit the etched and pitted attack often found in the field. From this it was concluded that the test would provide rapid and sufficiently valid evaluation of inhibitors for this service.

Results With Commercial Inhibitors

A majority of the best inhibitors of air-free hydrogen sulfide corrosion are high molecular weight substituted cyclic or heterocyclic amines. These materials adsorb to metal surfaces through the polar nitrogen groups and provide oily hydrophobic films (by virtue of the outwardly orientated hydrocarbon portion of the molecules.) Some of the normally oil soluble amines are reacted with enough ethylene oxide to be water soluble or dispersible. Water solubility is obtained in some compounds by neutralizing the amines with acetic acid.

Figure 2 shows the generic structure of two typical compounds and the result obtained when the materials were tested in the sulfide air system described above. Also listed are the results obtained with a soap made by neutralizing high molecular weight organic acids with soda ash. This material is very effective rust inhibitor but, like the straight sulfide inhibitors, it failed in the salt water solutions containing a combination of hydrogen sulfide and oxygen.

No clear cut explanation could be found for these failures. The inhibitors themselves apparently were not attacked by the corroding agents, but rather, the films seemed to break down mechanically. Some panels were protected over part of their surface but suffered very concentrated local attack. It could be postulated that inhibitor adsorption was strong at some areas and weak at others. What was needed was a material which would firmly adsorb over all the metal surface to form a close packed film impenetrable to the corroding agents.

Development of an Air-Sulfide Inhibitor

As experience was gained with the air-sulfide system, a large number of materials was suggested as inhibitors by members of the research group. Promising compounds were studied to determine what characteristics of molecular structure, functional groups and solubility have influence on inhibitive behavior. All desirable properties could not be found in a single compound. However, a proposed group of amine-acid complexes was tested and gave surprisingly good results.

For the preliminary work with these materials, a long chain primary aliphatic amine (Armeen 18) was used as the amine portion of the complex. This amine looked most promising for building an inhibitive film with optimum water repelling ability. It was visualized that the long normal hydrocarbon chains on the amine nitrogen would orient in close formation

with a minimum of mutual or steric hindrance which was believed to interfere with close adsorption of aromatic or heterocyclic amines. One possible disadvantage was that large amounts of this type of amine would be required to make a complete monomolecular layer if each molecule did stand rigidly perpendicular to the metal surface and covered only an area equal to its cross section.

For the acid component, a mixture of organic acids and associated compounds produced by liquid phase oxidation of hydrocarbons was selected. Reaction of the amine and acids yields a complex that is not considered to be a simple "soap" or "salt."⁴ The complex possesses good oil solubility not exhibited by either component.

Since neither the unreacted amine nor the unreacted acid gave good results alone in the sulfide-air test, a synergistic action was apparently obtained with the combination.

Successful results with the complex described led to immediate evaluation of many different combinations of amines and acids. Table 1 is a comparison of a representative group. No inhibitor concentrations or weight loss data are included because it is the relative effectiveness of the compounds that is of interest. The order of effectiveness was found to be generally independent of test conditions.

Aliphatic amines below C_{10} (10 carbon atoms in the chain) and carboxylic acids below C_5 did not yield successful inhibitors regardless of the molecular weight of the other component. Of particular interest is the sudden loss of inhibitive properties on going from decyl (C_{10}) amine to octyl (C_8) amine. The inhibitor made with C_{10} amine gave nearly complete protection but severe pitting was allowed by the inhibitor made with C_8 amine. The difference can be seen in Figure 3 which shows the test panels after exposure. No effort has been made to investigate the causes of this behavior, but it is believed to be due, at least in part, to the greater water solubility of the amines below C_{10} .

All the inhibitors made with refined acids, such as oleic, were reduced in effectiveness by the formation of water-in-oil emulsions. This is a serious handicap for inhibitors intended for use in oil wells. Even when unstable emulsions were formed with inhibitors made from pure acids, it was often found that test panels would be coated with a gummy emulsion. When this happened, the inhibitors did not have free access to all the metal surface and local pitting occurred. Inhibitors made with the mixture of oxygenated petroleum acids did not cause emulsions in these tests, but actually prevented stable emulsion formation.

Other Tests With the New Compounds

Further testing showed that the amine-oxygenated petroleum acid inhibitors would effectively retard corrosion caused by hydrogen sulfide alone and by organic acids.

The tests for hydrogen-sulfide corrosion inhibition were carried out using a static bottle test. This test has been in use in the Stanolind Oil and Gas Company laboratory since about 1944⁵ and has given good correlation with field results. Essentially the method

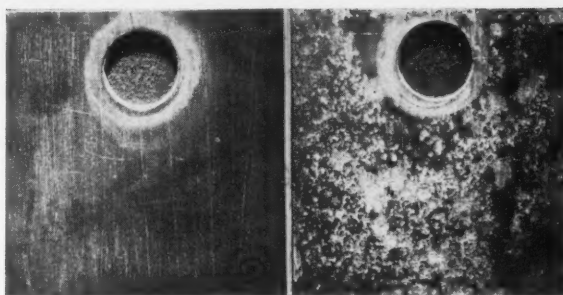


Figure 3—Test panel on left was inhibited with C_{10} amine-acid complex. Note the severe attack suffered by the right hand panel which was inhibited with C_8 amine-acid complex.

TABLE 1
Comparative Effectiveness of Some Amine-Acid Complexes

Amine	Acid	Percent Inhibition	Remarks
Octadecyl.....	Oxygenated Petroleum	99	Uniform Protection
Octadecyl.....	Ricinoleic	83	Uniform Protection
Octadecyl.....	Lauric	90	Uniform Protection
Octadecyl.....	Caprylic	79	Uniform Protection
Octadecyl.....	Acetic	63	Widespread Pitting
Dodecyl.....	Oxygenated Petroleum	87	Uniform Protection
Dodecyl.....	Lauric	85	Uniform Protection
Decyl.....	Oxygenated Petroleum	95	Uniform Protection
Octyl.....	Oxygenated Petroleum	70	Deep Pitting
Cyclohexyl.....	Oxygenated Petroleum	15	Deep Pitting

consists of exposing one-inch-square mild steel panels to deaerated sour brine contained in one liter flasks. An oil layer is present in which oil soluble inhibitors are dissolved. The test panels are dipped into the oil and then suspended in the brine phase for seven days. After exposure, the panels are cleaned and their weight losses are determined.

A somewhat similar test procedure was used in studying inhibition of corrosion by organic acids. In this case, however, the test panels are alternately exposed to oil and water phases with a dipping mechanism operating through a gas seal. The water, containing 500 ppm acetic acid and 5 percent NaCl by weight, is held near boiling temperature and a continuous stream of CO_2 is bubbled through it. Inhibitor efficiency is determined by the weight loss method.

The amine-oxygenated petroleum acid compounds gave 92-98 percent inhibition in both types of tests, at concentrations of 50-100 ppm.

Final Formulation

With regard to the amine component of the inhibitors, further experimentation led to the final adoption of the straight chain aliphatic structure. Branching in the carbon chains was found to be detrimental. It was discovered that the concentration of inhibitors made with the straight chain amines need not be very high to obtain excellent inhibition. This indicates that a large cross sectional area is not so important as previously thought.

Introduction of more than one nitrogen at the extremity of the amine molecule was found to have the desirable effect of increasing polarity and the strength of adsorption. Very likely the orientation on metal surfaces is also affected because the minimum concentration of inhibitor required for any

TABLE 2—Some Field Test Results
With the Amine-Oxygenated Petroleum Acid Inhibitor

LOCATION	Equip- ment Affected	Corro- sion Agent	Treating Rate	CORROSION RATE	
				Before Treatment	With Treatment
West Texas	Pump Rods	H ₂ S	Av. 2 Qts/day	20 Rod Breaks in 8 Mo.	1 Rod Break in 11 Mo.
East Texas...	Rods and Tubing	Rod on Tubing Wear (Salt Water)	1 Pt/day	16 Well Repairs in 12 Mos. Av. Expense \$850/Mo.	1 Well Repair in 13 Mos. Av. Expense \$8/Mo.
South Louisiana	Gas Well Tubing	Organic Acids (Carbon Dioxide)	3 Qts. Every 5 Days	Iron Content of Water 150-200 ppm	Iron Content of Water 0-26 ppm
North Louisiana	Wet Gas Line	Air	1-6 Qts/ MMCF Lubri- cated	2.5 MPY*	0.3 MPY*

* Mils Penetration per Year.

particular corrosive system is less than that required with an inhibitor made from a monoamine, that is, a single nitrogen amine.

A water dispersible form of the inhibitor was developed by adding specific emulsifiers and solvents to the base compound. Due to peculiar properties of the emulsifiers used, the inhibitor can be diluted with either fresh or salt water. The emulsions are finely divided oil-in-water types which do not cause the difficulties associated with the water-in-oil types previously mentioned. Dilution with salt water is very advantageous in many cases since the resulting mixture will circulate in wells with high fluid levels where oil or fresh water diluted inhibitors often fail.

Solid forms, containing the inhibitor, have been made for treating the tubing and casing of the wells where liquid treating is difficult due to the presence of a packer.

Field Testing

Final selection of components was based on all the factors just discussed and pilot manufacture and field testing was commenced. A brief consideration of field testing is included here since the laboratory development of an inhibitor is not complete until it is proved that the material selected will inhibit corrosion under field conditions.

For the initial tests, old shallow wells were selected which were experiencing severe corrosion caused by air gaining entrance through open casings and mixing with the sour production. Trials of other inhibitors had been unsuccessful and this verified laboratory results which indicated the materials would be ineffective. The oil-soluble form of the inhibitor reduced corrosion by 89 percent according to weight losses of untreated and treated rod subs.

Typical results from subsequent field tests are listed in Table 2.

The first example is taken from a West Texas field with over two years' experience with the new inhibitors. A review of all pulling jobs from the field reveals that since initiating the treatment, rod failures have declined from 36 to 10 per quarter, a reduction of 72 per cent. The initial failure rate was established while the wells were being treated with other inhibitors.

The East Texas example is an interesting application. Rod and tubing failures occur very rapidly in that area when water production of the wells exceeds about 150 barrels per day. The inhibitor treatment effectively retards this type of failure by inhibiting corrosion and providing a highly lubricating film which reduces wear. Field practice now is to start treatment in each well when it starts producing 100 barrels of water per day.

Treatment of gas wells has been very satisfactory as indicated by the case cited of a well in South Louisiana. Both the tubing and the casing of dually completed wells are treated.

The last example in Table 2, is a gas gathering system located in northern Louisiana. This line has suffered very severe corrosion by virtue of approximately 25 per cent air in the wet gas. Simply by lubricating the liquid oil-soluble inhibitor into the gas stream, the rate of attack was reduced about 88.5 per cent. This was determined by placing weighed pipe nipples in the line ahead and downstream from the point of chemical injection. The mils penetration per year figures reported were calculated from weight losses of the nipples. Good distribution of the inhibitor was verified by chemical tests which showed presence of the chemical in debris collected on a screen several miles from the point of injection.

Use of the new inhibitors has been extended to the majority of Stanolind's corrosive wells, both sour and sweet, in which a non-volatile compound can be used. At present, about 1000 wells are being treated and no handling difficulties have been reported because the material is non-irritating and has no objectionable odor.

Conclusions

1. A new series of inhibitors has been developed which has proved effective against most types of corrosion encountered in the oil producing industry.
2. The development work has been traced from the original problem to the application of the new inhibitors in the field, to demonstrate the pattern of investigation used.

References

1. F. A. Prange. *Oil Gas J.*, **45**, 88-90 (1946) Sept.
2. W. F. Rodgers. *Corrosion*, **2**, 59 (1946) March.
3. USWM Rept. Investigations 3160, Feb. 1932.
4. *Lubrication Engineering*, **37**, 117 (1951) June.
5. P. L. Manual. *World Oil*, **120**, 150-152 (1947) Oct.

Material Selection for Condenser Tubes*

By HAROLD A. TODHUNTER*

IN THE SELECTION of tube material for sea water condensers, two main factors to be considered are: first, the water conditions that must be contended with, and second, the design features of the cooling water system that may affect condenser tube performance or life. In the following analysis of condenser tube materials, the effect of the cooling water velocity in the condenser tubes is shown to be an important factor. A study is made of the costs of the entire cooling water system to show relative costs of cooling water systems for different velocities.

In analyzing the water conditions for some condenser tube installations, it is necessary only to determine the water conditions that prevail in the area and to decide what condenser tube alloy will work the best for that particular water. In other cases, it may be possible to alter the water conditions that exist in order that a standard condenser tube alloy can be used or in order that the life of the condenser tubes already in service may be increased.

However, consider a bad water condition that may exist and what may be done to improve it. It may be that the cooling water is badly polluted with sewage or organic waste. If this is the case, at best the dissolved oxygen normally in sea water may be partly depleted and at worst when the oxygen is completely depleted, dissolved hydrogen sulphide may be found in the cooling water. In the latter case, it is likely that anaerobic bacteria are living in the water. These bacteria which may exist in highly polluted water may live in the slime on the tube walls. Under these conditions, deterioration of brass tubing is accelerated by the sulfur compounds secreted by the anaerobic bacteria. At the Harbor Steam Plant of the City of Los Angeles, pollution of this type existed for several years during the period from 1944 to 1948 and while the condition was at its worst, aluminum brass condenser tubes in sea water surface condensers were failing after approximately one year's service.

Condition Favored Anaerobic Bacteria

Figure 1 shows the amount of dissolved oxygen and dissolved hydrogen sulphide in this cooling water during the period in question. The curves show the variation in both the oxygen and hydrogen sulfide. It is interesting to note that oxygen and hydrogen sulfide do not occur at the same time. The pollutant appeared to consume the dissolved oxygen during the natural process of decomposition. After the oxygen was consumed, further decomposition resulted in the formation of hydrogen sulfide and pro-



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Abstract

Factors involved in the design and operation of sea water condensers are discussed. These include water conditions and design factors which may affect condenser tubes life. Effect of water velocity is surveyed and a study is given of relative costs of cooling water systems for different velocities. Specific cases are cited involving Los Angeles Harbor water including methods considered and used to regulate animal and plant life. Effects of chemicals, galvanic action and design of tubes of various alloys are explored. Economic data involved are cost of fuel, generating capacity, expectant life of plant and other criteria. An appendix gives a brief history of 1500 tubes installed in a sea water condenser in August, 1947.

duced a favorable condition for anaerobic bacteria. Figure 1 also shows the rate at which chlorine was used during the time the water was badly polluted. In order to maintain an 0.25 parts per million residual of chlorine at the condenser outlet, the chlorine feed ranged as high as 29 parts per million.

Clean Up Campaign Started

During 1946 it was realized that pollution of the cooling water was causing extensive damage to condenser tubes and also necessitated use of large quantities of chlorine for controlling slime in the tubes. At that time a campaign was started to clean up the cooling water in the Los Angeles Inner Harbor. It was found, after working with others in the area, that the City of Los Angeles was not the only one adversely affected by the bad water conditions and that many others were interested in the clean-up program.

During the following three or four years, the organized efforts of those interested in improving the Los Angeles Inner Harbor water conditions resulted in elimination of the hydrogen sulfide and anaerobic bacteria in these waters. Since then the dissolved oxygen has increased to three or more parts per million and marine life requiring oxygen has returned. The result was that there are now shell fish, squid, anchovies and other marine organisms which are objectionable from other points of view.

*A paper presented at a meeting of Western Region, National Association of Corrosion Engineers, Los Angeles, November 18-19, 1954.

*Steam Design Engineer, Department of Water and Power, City of Los Angeles.

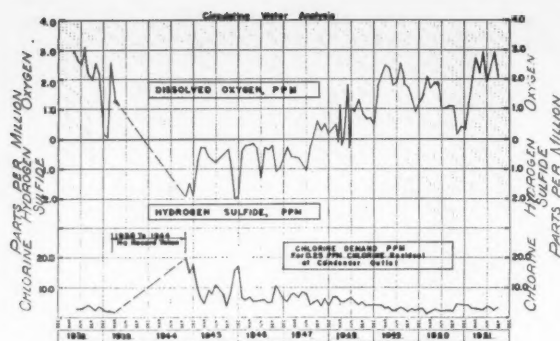


Figure 1—Circulating water analysis.

However, condenser tubes last from 5 to ten years now instead of one year, as was the case when pollution was at its worst.

Other Ways to Extend Tube Life

There are many other ways of improving condenser tube performance within immediate control of the company using the tubes. Some of these are the use of chlorine or bromine, the installation of screens and the use of other schemes to control marine life which might jeopardize the service of the condenser tubes. Chlorine and bromine are generally used to control slime on the condenser tube walls. These chemicals also may be used to control mussels which live and grow in the cooling water system. Other means of controlling mussels are by thermal shock, by depletion of oxygen and by increasing the water velocity in the tunnels.

The use of thermal shock has been considered a desirable way to control mussels. This is done by reversing the cooling water flow in the tunnels so that the heated cooling water is discharged through the inlet tunnels. Raising the water temperature in the inlet tunnels 30 to 40 degrees will kill most of the mussels in a short time. If this is done periodically, the mussels will never grow large enough to lodge in a condenser tube and cause a partial obstruction to flow. Water in the tunnels also could be heated by specially designed heat exchangers that would accomplish the same or even more effective results.

Mussels Killed by Removing Oxygen

If the water is supplied to the condensers by two or more submerged tunnels, the mussels in the tunnels may be killed by shutting off their oxygen supply. This is done by stopping the flow of water in a tunnel, thus allowing the water in that tunnel to become stagnant. Several days may be required to suffocate the mussels by this procedure.

It has proved practical also to get rid of large quantities of mussels by increasing the water velocity in a particular tunnel for a short period. This can be accomplished only if there are two or more inlet tunnels and the installation is arranged so that one or more of these tunnels can be blocked off and all of the cooling water forced through the remaining tunnel. This removes only a part of the mussels and creates the problem of disposing of the ones that are washed loose.

Screens Do Not Solve Problem Fully

Of course, the installation of well designed screens are quite necessary where the mussel problem exists, but even with well designed traveling screens with 1/2-inch mesh screen wire, many mussels get through to condensers and lodge in the condenser tubes. These mussels, as well as any other foreign matter which may lodge in condenser tubes, will cause an increased rate of condenser tube failure. This increase in tube failure is largely a result of the increased cooling water velocity around the lodged obstruction in the condenser tube.

One additional cause of early condenser tube deterioration is the improper use of some chemicals. For instance, the extensive use of chlorine may cause the condenser tubes to corrode at an increased rate. The presence of small amounts of ammonia in the cooling water or on the shell side of the tubes may cause stress corrosion which would result in early tube failure.

Galvanic Corrosion Is Damaging

Galvanic action sometimes causes serious deterioration of the tube sheets and the tube ends when conditions develop that cause these parts to be less noble than some of the nearby parts of the water boxes or piping. The effect of galvanic action of this type appears to occur at a more rapid rate at the tube inlets where unusual turbulence exists. Corrosion of this type has been noted in City of Los Angeles sea water surface condensers that have cast iron water boxes. The graphitic corrosion in the cast iron water boxes apparently changes the potential or nobility of the corroded surface so that it is more noble than the tube ends and the tube sheets. This causes increased galvanic action on the non-ferrous tube ends and tube sheets.

In addition to the problem of analyzing the water condition, the marine organisms that must be dealt with and the effects of chemicals used to control them, the engineer buying condenser tubes should take into consideration the design features of the equipment affecting condenser tube performance. These design features usually affect the condenser tube performance by changing the cooling water velocity or turbulence. This velocity or turbulence as previously mentioned also is affected by lodged obstructions in the tubes. Resultant velocity expected in the tubes should be taken into consideration in designing the equipment and selecting the tubes.

Factors in Tube Selection

Selection of a condenser tube alloy for a particular condition should be made with the assistance of the research departments of companies making condenser tubes. Most manufacturers of non-ferrous tubes make condenser tubes of all of the non-ferrous alloys generally used. Their research engineers can recommend the most desirable alloy for a given operating condition. They must know, of course, the quality of the cooling water, the temperature ranges through which the water may operate and the water velocity to be used in the tubes. For instance, inhibited Admiralty metal can be expected to give good

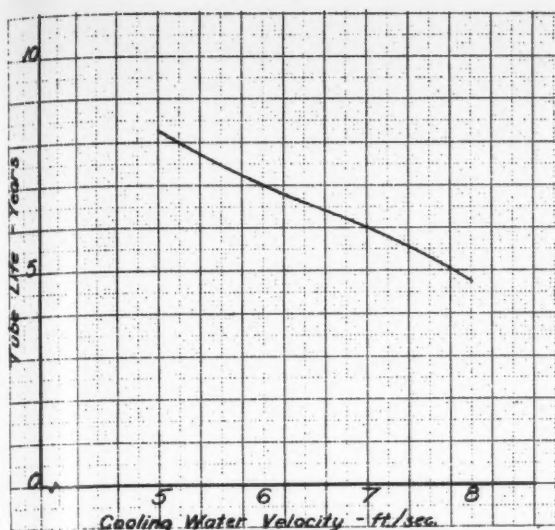


Figure 2—Condenser study. Tube life vs cooling water velocity. Sea water cooling, 156 MW unit.

service in clean sea water for temperatures up to approximately 100 F and for cooling water velocities up to approximately 5 feet per second; while aluminum brass, aluminum bronze and cupro nickel tubes have been developed to give dependable service for higher cooling water velocities. Each of these alloys has a range of operating conditions for which it is especially recommended. It should be remembered, however, that condenser tubes will not give unvarying service throughout the recommended range of cooling water velocities. Because of this, it should be expected that performance of the tube will vary with the velocity of the cooling water.

On the basis of a study made for a new steam plant for the Department of Water and Power, it was estimated that these tubes operating with a velocity of 5 feet per second would last about 8 years and those with a velocity of 8 feet per second would last only 5 years. The curve showing these conclusions is shown in Figure 2. The slope of the curve is the

important factor to determine in making a condenser tube study. Tube life will be affected not only by the quality of the water but also by the foreign matter that may become lodged in the tubes.

Careful Economic Study Required

To finally analyze a particular problem and to determine the type of condenser tubes that should be used, a careful economic study should be made of the recommended alloys. The expected life of the recommended alloys should be determined for cooling water velocities ranging from approximately 4 to 8 or more feet per second. Some of the important independent variables that need to be considered in the final study are as follows:

1. Condenser tube material.
2. Condenser tube length.
3. Condenser tube diameter.
4. Number of tubes.
5. Number of cooling water passes in the condenser.
6. Cooling water velocity.
7. Condenser vacuum.
8. Cooling water system supplying the condenser.

Table 1 shows the capital charges that should be determined. This table is a list of major items of equipment that are needed for a cooling water system. The items listed are the ones that may be expected to vary in an evaluation study of a cooling water system.

Some of the data that must be assessed in making the study are:

1. Cost of fuel or electric energy.

TABLE 2
Annual Operating Expenses for Consideration in a
Condenser Tube Study

	Case 1	Case 2
Condenser Area, Sq. Ft.		
Annual Operating Expense		
Fixed Charges		
1. Condenser (Less Tubes)		
2. Condenser Tubes for:		
a. 5 ft/sec Velocity		
b. 6 ft/sec Velocity		
c. 7 ft/sec Velocity		
d. 8 ft/sec Velocity		
3. Foundations & Structure		
4. Intake & Discharge Tunnels		
5. Pump Chamber		
6. Traveling Screens		
7. Circulating Water Piping & Valves		
8. Circulating Water Pumps		
9. Charge for Capacity to Serve Circulating Water Pumps		
Operation and Maintenance		
10. Condenser (Less Tubes)		
11. Condenser Tubes for:		
a. 5 ft/sec Velocity		
b. 6 ft/sec Velocity		
c. 7 ft/sec Velocity		
d. 8 ft/sec Velocity		
12. Intake & Discharge Tunnels		
13. Pump Chamber		
14. Traveling Screens		
15. Circulating Water Piping & Valves		
16. Circulating Water Pumps		
17. Energy Cost for Circulating Water Pumps		
18. Added Fuel for Back Pressure Above 1.0 In. Hg. Abs. for Fuel Price Assumed		
19. Credit for Added Capability Capacity for Back Pressure Below 3.5 In. Hg. Abs.		

TABLE 1

Pertinent Factors for Consideration in a Condenser Tube Study

	Case 1	Case 2
Condenser Area, Sq. Ft.		
Important Independent Variables		
1. Condenser Tube Material		
2. Condenser Tube Length, Ft.		
3. Condenser Tube Diameter, Inches		
4. Number of Tubes		
5. Number of Cooling Water Passes in the Condenser		
6. Cooling Water Velocity, fps		
7. Condenser Pressure, in. Hg. Abs.		
8. Circulating Water, gpm		
Capital Charges		
1. Condenser (Less Tubes)		
2. Condenser Tubes		
3. Foundation & Structure Increments		
4. Intake & Discharge Tunnels		
5. Pump Chamber		
6. Traveling Screens		
7. Circulating Water Piping & Valves		
8. Circulating Water Pumps		
9. Charge for Capacity to Serve Circulating Water Pumps		

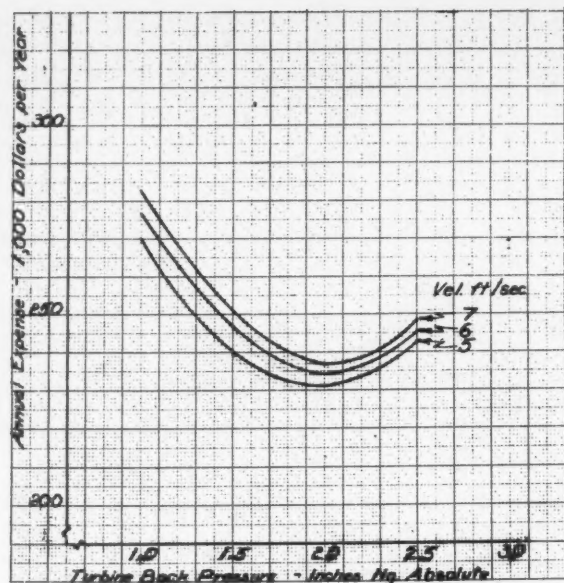


Figure 3—Condenser study. Annual expense vs turbine back pressure. One pass, 40-foot tubes, sea water cooling.

2. Cost of generating capacity or electric demand.
3. Expected life of the plant.
4. Cooling water temperature.
5. Condenser tube cleanliness factor.
6. Load condition on the turbine.

Table 2 shows the various annual operating expenses that should be considered. The annual operating expense for these various items of equipment should be determined for the installed equipment using the appropriate interest rates and depreciation factors for the installation under consideration. Economic principles of various companies differ appreciably, so procedure for determining these costs should be set-up in accordance with the established policies of the company involved.

The condenser is listed without tubes so that the annual expense for condenser tubes may be based on the actual expected life of the tubes being studied. The charge for capacity to serve the circulating water pumps is the charge that should be made for the installed plant capacity to serve these pumps or it may be considered as a demand charge for electricity.

Operation and maintenance of the condenser tubes will vary with the water velocity in the tubes and should be considered in this study. Other operation and maintenance expenses may be estimated as a percentage of the capital charges shown in Table 1 for the equipment involved. Energy used by the circulating water pumps can be computed from the fuel cost or from energy charges for electricity. Data for capital charges and the annual operating expense should be tabulated for the various combinations of independent variables, as indicated on Table 1, that appear to be of interest to the designer. In some cases, the tube length and diameter may be dictated by space requirements. The number of passes also may be determined by the building arrangement. However, it should be noted that longer tube lengths

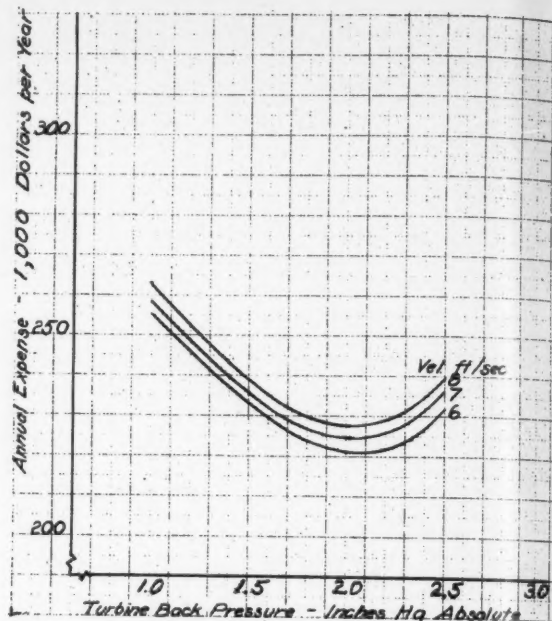


Figure 4—Condenser study. Annual expense vs turbine back pressure. Two pass, 30-foot tubes, sea water cooling.

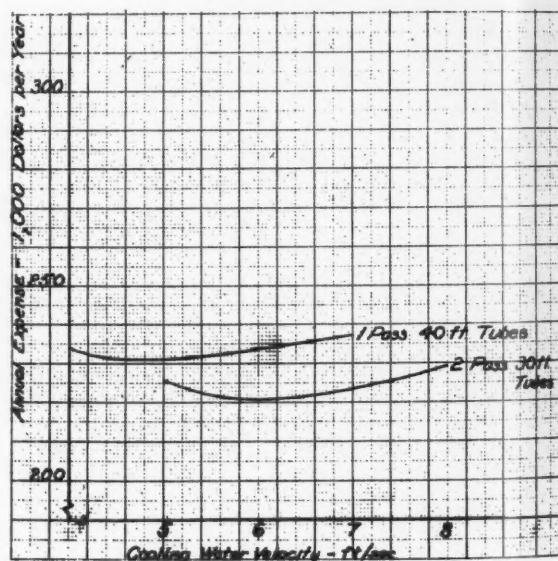


Figure 5—Condenser tube cooling water velocity study. Annual expense vs CW velocity. Condenser pressure 2.0 inches Hg abs. sea water cooling 156 MW unit.

can be used more effectively in single pass condensers than in 2-pass condensers.

Cases should be studied for various size condensers so that curves as shown in Figures 3 and 4 can be plotted. These curves of annual expense plotted against turbine back pressure should show a minimum cost point if an adequate range of turbine back pressures are studied. For each particular condenser being studied, it can be determined from the curves the turbine back pressure that will give the minimum annual expense. Cooling water velocity required to give this minimum annual expense can be computed

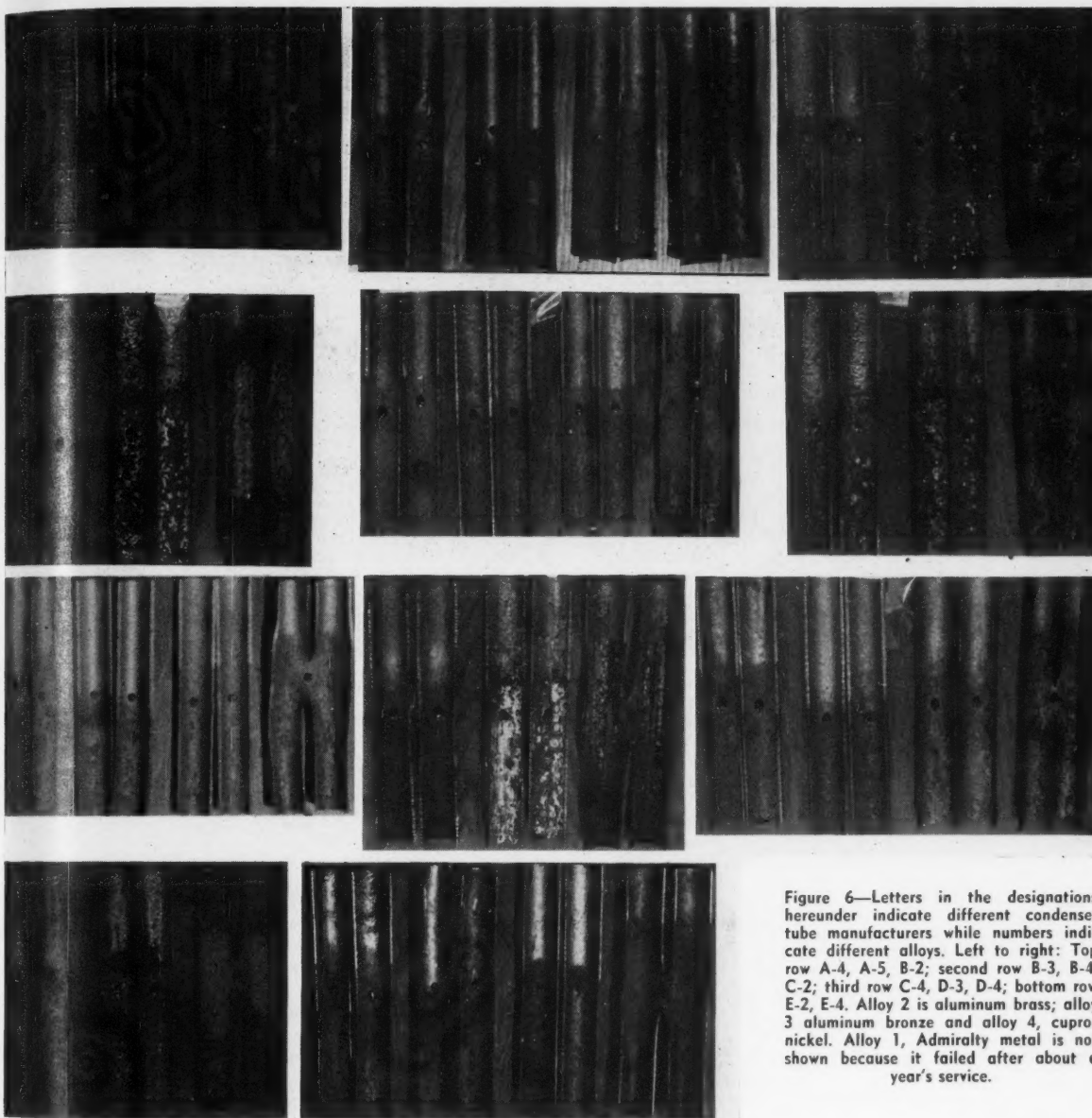


Figure 6—Letters in the designations hereunder indicate different condenser tube manufacturers while numbers indicate different alloys. Left to right: Top row A-4, A-5, B-2; second row B-3, B-4, C-2; third row C-4, D-3, D-4; bottom row E-2, E-4. Alloy 2 is aluminum brass; alloy 3 aluminum bronze and alloy 4, cupro-nickel. Alloy 1, Admiralty metal is not shown because it failed after about a year's service.

and as shown in Figure 5, the resultant cooling water velocity can be plotted against annual expense. The minimum annual expense points shown on the curves, Figures 3 and 4, are the points determined in a preliminary condenser study for a large sea water installation and should not be considered as showing recommended velocities or annual costs. However, the large decrease in annual expense of approximately \$30,000, when the turbine back pressure is changed from 1 to 2 inches Hg absolute is indicative of the variation in magnitude of annual expense involved in a study of the cooling water system for a large power generating unit.

In summing up the important considerations to be made in choosing a condenser tube alloy, it is essential to realize the importance of cooling water velocity in the condenser tubes and the importance

of the pumping, corrosion and maintenance costs that are directly chargeable to the cooling water system. When this is done, the difference in first cost of the various condenser tube alloys becomes much less important.

As a result of such studies and detailed condenser tube tests at Harbor Steam Plant, 70-30 cupro nickel were chosen.

In Harbor Steam Plant's future sea water condenser installations, 70-30 cupro nickel condenser tubes most likely will be used again and a careful study will be made to determine the optimum cooling water quantities and velocities.

Appendix 1

Approximately 1500 condenser test tubes were installed in Unit 2B sea water condenser at the De-

partment's Harbor Steam Plant in August 1947. These sample test tubes were removed during the past few years. The condenser is a 60,000 square foot twin shell unit that receives its cooling water from Slip 5 of the Los Angeles Inner Harbor. The cooling water velocity in the tubes is approximately $7\frac{1}{4}$ feet per second.

Figure 6 shows samples of the test tubes studied during this test. The sample on the left side of each picture was removed after approximately 5000 hours of service while the sample on the right side was removed after approximately 50,000 hours of service. The intermediate samples have had approximately 15,000 hours of service. Each picture shows a sepa-

rate alloy furnished by one of five condenser tube manufacturers. The letters in the caption indicate different condenser tube manufacturers while the numbers indicate different alloys. No. 2 indicates aluminum brass, No. 3 aluminum bronze, and No. 4, 70-30 cupro nickel.

Alloy No. 1 was Admiralty metal and is not illustrated because the failure rate of the Admiralty tubes became excessive with approximately one year's service, after which they were removed from the condenser.

The cupro nickel alloy with approximately $\frac{1}{2}$ per cent iron shows the best record of performance.

ERRATA

Minimizing Stress Corrosion Cracking of Cylinder Valves by M. Schussler. Corrosion, Vol. 11, No. 3, 19-22 (1955) Mar.

Page 20, cutlines, Figure 4, third line should read:

stringers of eutectoid and has a hardness of Rockwell B85. Etchant:

correcting the spelling of "Rockwell."

Page 20, column 2, line 6 should read:

(Rockwell B65) has more alpha and less eutectoid

changing the letter following Rockwell to "B."

Proposed Methods for Cathodic Protection of Composite Structures by M. Unz. Corrosion, 11, 40-43 (1955) Feb. Page 40. Biography. Third and fourth lines to read:

Tel Aviv. He is attending to a cathodic protection scheme of the Mekoroth Water Company

Page 41, column 2, Table 1. For the last line of the table substitute the following:

voltage, | U | , expected, volt-0.85 -0.95

correcting the values for voltage.

Economic Considerations in Pipe Line Corrosion Control*

By L. G. SHARPE

Introduction

THE PIPE LINE corrosion engineer's job is to reduce costs. Everything he does is incidental to that task. Developing superior materials or devising improved methods are, for him, not ends in themselves but means to an end. The only real basis for selection of materials or methods is the economy which may be obtained by their use.

Many authors, in describing solutions of pipe line corrosion problems, include statements of the costs involved but few papers are to be found in which the economics of the various methods of corrosion control are thoroughly examined and compared. Such examinations and comparisons are needed to stimulate and guide new developments. They are needed as a basis for selecting the most economical of alternative methods.

The object of this paper is to examine the economics of three separate pipe line corrosion problems:

- 1) internal corrosion in sour crude oil pipe lines
- 2) external corrosion of storage tank bottoms
- 3) external corrosion of buried pipe lines.

Internal corrosion in pipe lines handling sour crude oil is a problem of no small magnitude, yet the published literature contains scant information on the subject. Within the past five years the problem has been attacked rather aggressively and published information can be expected to increase. This paper reports briefly on effectiveness and costs of the various methods in use by the industry to combat internal corrosion and compares the economics of their use. All of the corrosion control methods can effect major savings.

Techniques for cathodic protection of tank bottoms have been adequately described in a number of published papers. A comparison of the cost of tank bottom corrosion for an entire pipe line system with that of cathodic protection for the same system indicates that much more widespread use of cathodic protection is justified.

Since 1930, when the National Bureau of Standards' underground pipe line coating tests were started, pipe line coating practices have been undergoing continual improvement to increase effectiveness of the coatings. Concurrent development of cathodic protection (introduced early in the '30's, gradually accepted and, starting in the middle '40's, extensively applied) now has a strong bearing on pipe



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Abstract

Three major corrosion problems encountered in pipe line operation are considered. Experience with the various corrosion control methods is described and the economics of their use is examined.

Internal Corrosion in Sour Crude Oil Pipe Lines—For controlling internal corrosion in sour crude oil pipe lines, corrosion inhibitors, regular scraper runs, internal coatings, concrete lining, asbestos-cement pipe and plastic pipe all are effective and economical. Cost comparisons for two average sour crude oil gathering lines indicate that 1) in general, concrete linings and corrosion inhibitors appear most economical in the longer, larger lines while concrete linings, internal plastic coatings and plastic pipe appear most economical for the shorter, smaller lines, but, 2) all of the protective measures provide major savings—from at least 9 cents to as much as 25.5 cents per foot of pipe per year.

External Corrosion of Oil Storage Tank Bottoms—Slightly more than 5 percent of the unprotected oil storage tank bottoms in a large pipe line system fail each year as a result of soil corrosion. Cathodic protection effectively controls corrosion at an average installation cost of \$410 per tank and an average total operating expense of \$62 per tank per year. This installation cost is equivalent to about 3 percent of tank bottom investment; the total annual operating expense is equivalent to about 1¼ percent of one repair job. Protection of all remaining unprotected tank bottoms in the system would have an indicated payout of 1½ years; the total annual operating expense of such protection would amount to about 25 percent of the present annual direct cost of tank bottom repair.

External Pipe Coatings and Cathodic Protection—Substantial coatings supplemented with cathodic protection are used generally for preventing external corrosion of buried pipe lines. Examination of the relationship between coating practices and costs and cathodic protection requirements and costs indicates that: 1) For minimum total cost coatings are needed; 2) Even the best pipe line enamel coatings are not free from imperfections and require supplementary cathodic protection for full protection of the pipe; 3) The cost of cathodic protection on reasonably well-coated lines is so small that the large expense and effort required to secure more than reasonably good coating jobs are difficult to justify. Items of such expense include coating reinforcements, complete holiday detector inspection, rigid insistence on holiday-free construction, rock shield, ditch padding.

*A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, Tulsa, Okla., Oct. 7-9, 1953 and the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.

line coating requirements. The combination of substantial coatings supplemented with cathodic protection is repeatedly reported to provide complete protection most economically. However, the relationship between coating practices and costs and cathodic protection costs has not been adequately explored. To initiate such an examination, data are given and costs are compared which question the justification of some coating practices.

Internal Corrosion in Sour Crude Oil Pipe Lines

A. Extent of the Problem

The API Sub-Committee on Internal Corrosion of Crude Oil Pipe Lines and Tanks has convassed its membership to determine the magnitude of the internal sour crude corrosion problem and to determine the extent to which corrosion control methods are in use.

Fortunately, serious internal pipe line corrosion is limited to the relatively few sour crude oil producing areas. The Permian Basin in West Texas and the Magnolia field in Arkansas are typical.¹

In the most severe service reported, new steel pipe lasts only 1½ years before the first major repair or replacement is required. The average service life of pipe in sour crude gathering service is about 5 to 7 years. Although a number of different means of controlling corrosion were reported effective, they are in limited use.²

B. Causes of Internal Corrosion

Trunk lines which operate continuously at reasonably high velocities suffer negligible internal attack, if any at all, from sour crudes. On the other hand, gathering lines and station lines operating intermittently or at low stream velocity are severely attacked. Furthermore, attack occurs only on the lower portions of the pipe with little or none along the upper surfaces. Corrosion is attributed to the action of sour brine and sulfide scale settling out in the bottom of the pipe.³

C. Effectiveness and Costs of Corrosion Control Measures

During the week of September 8, 1952, operating and engineering personnel of several pipe line companies met informally in West Texas to discuss methods of combatting internal sour crude corrosion. Representatives of Gulf, Magnolia, Interstate, Shell and Humble Pipe Line Companies participated. The following is a summary of the findings of the conference with some additions and corrections to bring it up to date.

1. Inhibitors and Scrapers—Several types of inhibitors are in trial use. Continuous injection of some organic inhibitors in very small concentrations has given excellent protection. These materials give equally good protection at considerably lower cost when a small batch is moved through a line behind a scraper once a week. Continuous treatment with zinc dust or a soluble zinc salt was reported to have substantially reduced corrosion rates.

Because of internal corrosion in one 6-inch line 30

miles long in West Texas, 5 miles of pipe had to be replaced and the balance turned 180 degrees and patched during the first 9 years of operation. Cost of maintaining this line, including costs of leak repairs, lost oil and reconditioning over a 10 year period, averaged 24 cents per foot per year. From November, 1951 to January, 1953, 15 gallons of inhibitor was moved through the line behind a scraper once a week. Although seven leaks occurred in the line in October, 1951, the month before treatment was started only 4 occurred during the 14 months' treatment. Corrosion coupons and spools in the line during the period of treatment showed no evidence of corrosion.

In order to determine the effect of scrapers alone, the inhibitor batches were discontinued in January, 1953, but weekly running of scrapers was continued. Inspection of coupons and test spools after 3 months showed scattered pitting. The scrapers alone reduced pit frequency but did not reduce the rate of penetration of the pits which did form. This was considered inadequate for this line so weekly batch inhibitor treatment was resumed and is being continued.

Although the minimum amounts of organic inhibitors needed for corrosion control have not yet been fully established, cost of continuous injection is about 1 to 3 mils per barrel of crude. Cost of batch treatment is dependent on size and length of line more than upon amount of oil handled. In the case described treatment costs about 1½ cents per foot of pipe per year. Cost of zinc injection is about 0.3 mils per barrel of crude.

2. Internal Plastic Coating—During the past five years, methods of applying plastic coatings internally in pipe lines in place have been developed.⁴ While considerable improvements in coating materials and in techniques of cleaning the lines and applying the coatings are being made, experience has indicated good performance even from the earlier coatings. Life of satisfactorily applied coatings has not yet been established. From 7 to 10 years appears at the moment to be a realistic estimate.

Coating costs vary, depending on contractor, coating materials, application methods, condition of pipe, terrain, weather, etc., but current coating costs are about 30-35 cents per foot for 4-inch; 45-55 cents for 6-inch; 60-70 cents for 8-inch pipe.

Plastic coatings shop-applied in screw end pipe cost about the same. While experience on performance is meager, they can be expected to equal the in-place applied coatings.

3. Concrete-Lined Steel Pipe—Concrete-lined pipe has given leak-free service for as long as 20 years. The linings appear to have an indefinitely long life. Lining costs are 20 to 40 percent of the cost of unlined new pipe: about 30 to 35 cents per foot for 4-inch, 45 to 60 cents for 6-inch, 55 to 70 cents for 8-inch pipe. In West Texas, total construction cost for laying concrete-lined pipe is only slightly higher than for unlined steel pipe: Cost of hauling and stringing is 20 to 30 percent more; cost of welding is 5 to 10 percent more. Other construction costs are

the same for lined as for unlined pipe. The total installed cost of a welded pipe line constructed of concrete-lined 2nd class pipe is just about the same as that of unlined new pipe.

4. Asbestos Cement Pipe—Asbestos cement pipe has been used in gravity lines and in low pressure discharge systems for about 15 years. The pipe is resistant to corrosion and deterioration but leakage at the joints and occasional breaks from bending stresses in the ground have been experienced. Cost of the pipe is about the same as new steel pipe but laying costs are relatively high because a level, padded ditch bottom must be provided to prevent breakage of the pipe from bending stresses.

5. Plastic Pipe—Pipe of several types of plastic is receiving considerable attention and is used to a moderate extent by a number of companies. Glass reinforced polyester, rigid vinyl and modified styrene are undergoing development. Extruded cellulose acetate butyrate pipe has been in sour crude oil service

for 5 or 6 years with no apparent deterioration. This pipe is extensively used by some gas companies for service connections. It is limited to low pressure service.

Although the cost of the pipe is somewhat higher than steel pipe of comparable size, its light weight and easy make up permits laying at high rates of progress with minimum crews and without heavy equipment. Lower laying costs compensate for higher material costs so that in many cases the total cost of plastic pipe lines in the ground is about the same as that of steel lines.

6. Cost Comparisons—While each of these methods is effective and economical in combating internal corrosion, no one of them is most economical for all systems—each seems to have its own place. Pipe size, length of line, operating pressure, operating schedule, amount of oil handled and length of time the line is expected to be needed are some of the factors which determine which is most suitable and economical for a particular line.

To compare the economics of these various methods of controlling internal pipe line corrosion, two hypothetical pipe lines are considered: 1) a long, large diameter, high pressure gathering line needed for a reasonably long time—a 50-mile, 12-inch discharge to serve a field with an expected 30-year life, and, 2) a short, smaller diameter, low pressure line needed for a reasonably short time—a 5-mile, 4-inch gravity line needed for an estimated 14 years.

Costs of installing and maintaining these two lines using the various protective measures are shown in

TABLE 1

Cost Comparison for Various Methods of Controlling Internal Corrosion in a Hypothetical Fifty-Mile 12-Inch Discharge. Required Life Thirty Years.

1. Unprotected Pipe: New PE pipe; 15 years service until replacement is necessary; 300 leaks occur during first 15 years and additional 300 leaks during second 15 years.
2. Inhibitor Program: Second Class pipe; inhibitor batched weekly; more than 30 years' service; 10 leaks occur during 30 years.
3. Concrete-Lined Pipe: Second Class pipe; more than 30 years' service; no leaks.
4. Plastic Coating: Second Class pipe; life of coating 10 years, line re-coated in place at 10-year intervals; service life of pipe more than 30 years; 10 leaks.

	(1) Unprotected Steel Pipe	(2) Inhibitor	(3) Concrete Lining	(4) Plastic Coating
Capital Investment—Line in Place—Cost per Ft.	\$ 4.78	\$ 3.44	\$ 4.23	\$ 4.14
Maintenance Cost for 30 year period, cost per ft.				
Replacement of Line.....	\$ 4.78	.....	.....	0.02
Leaks (\$400 each).....	0.91	0.02	.....	1.40
Recoating line.....	.....	0.40	.....	.....
Inhibitor cost, batch treatment.....	.....	.....	.....	.....
Total 30-Year Cost, including original investment but excluding salvage value.....	\$10.47	\$ 3.86	\$ 4.23	\$ 5.56
Cost per Foot, per Year.....	\$ 0.35	\$ 0.13	\$ 0.14	\$ 0.19

Note: Pressure requirements preclude use of plastic pipe or asbestos cement pipe.

TABLE 2

Cost Comparison for Various Methods of Controlling Internal Corrosion in a Hypothetical 4-Inch Gravity Line, 5 Miles Long With Required Life of 14 Years.

1. Unprotected Pipe: New, PE pipe; 7 years service until major repair required; 7 additional years service obtained by turning 180 degrees and patching; 100 leaks occur during first 7 years and an additional 100 leaks during second 7 years.
2. Concrete Lined Pipe: 4-inch 3rd Class PE pipe; more than 14 years service; no leaks.
3. Plastic Pipe: Class 100; more than 14 years service; 4 leaks.
4. Plastic Coating:
 - (a) 2nd Class pipe; coating life 7 years; recoated in place at end of 7 years; no leaks.
 - (b) 2nd Class pipe; coating life 7 years; second 7 years no protection; 100 leaks.
5. Asbestos Cement Pipe: Class 100; more than 14 years service; 20 leaks.
6. Corrosion Inhibitor: 2nd Class Pipe; Inhibitor batched weekly; more than 14 years service; no leaks.
7. Scraper Program: New pipe; scraper run weekly; 14 years service; 50 leaks.

	(1) Unprotected Steel Pipe	(2) Concrete Lining	(3) Plastic Pipe	(4) Plastic Coating		(5) Asbestos Cement	(6) Inhibitor	(7) Scrapers
				(a)	(b)			
Capital Investment—Line in Place, Cost per Ft.	\$ 1.40	\$ 1.12	\$ 1.42	\$ 1.35	\$ 1.35	\$ 1.50	\$ 1.07	\$ 1.40
Maintenance Cost for 14 Year Period, Cost per Ft.:								
Reconditioning and Turning Line.....	0.25	.....	.....	.....	.....	.....	.....	.....
Leaks (\$400 each).....	3.03	.....	0.06	.....	1.51	0.30	.....	0.76
Recoating.....	.....	.....	.....	0.28	.....	.....	.....	.....
Inhibitor and Labor Cost.....	.....	.....	.....	.....	.....	.....	0.83	.....
Scraper and Labor Cost.....	.....	.....	.....	.....	.....	.....	.....	0.20
Total 14 Year Cost, Including Original Investment, but excluding Salvage Value.....	\$4.68	\$1.12	\$1.48	\$ 1.63	\$2.86	\$ 1.80	\$ 1.90	\$ 2.36
Cost Per Foot, Per Year.....	33½¢	8¢	10½¢	11½¢	20½¢	13¢	13½¢	17¢

Tables 1 and 2. While costs of installation and maintenance will vary between systems and between operators, the tabulated figures represent average experiences of a representative group of operators.

D. Conclusions

The comparisons show that, 1) in general, concrete lining and inhibitors appear most economical in the longer, larger lines while concrete lining, plastic coating and plastic pipe appear most economical for the shorter, smaller lines, but, 2) *all* of the protective measures provide major savings—from at least 9 cents to as much as 25½ cents per foot of pipe per year.

It should be pointed out that in relation to profits, capital expenditure is twice as costly as operating expense, assuming a 50 percent income tax. This consideration increases the advantage of corrosion control means in which the cost is largely charged to operations.

External Corrosion of Oil Storage Tank Bottoms

A. Cost of External Tank Bottom Corrosion

During the years 1951 and 1952, 31 steel tank bottoms of one company failed as a result of soil corrosion. The direct cost of repairing these failures totaled \$162,500, an average of \$81,250 per year. This was only the direct cost of making the bottom repairs. The costs involved in removing the tanks from service, preparing the bottoms for repair, inspecting contract work and returning the tanks to service are not included.

All 31 bottoms were 80 feet in diameter and larger. Direct repair cost averaged \$5230 per bottom. Typical unit costs for the several methods of bottom repair are given in Table 3.

The 31 failures were equivalent to 10½ percent of all the unprotected steel bottoms 80 feet in diameter and larger in service during the two years.

B. Effectiveness of Protection

Humble Pipe Line Company's Webster Station was placed under cathodic protection in 1941.⁵ In 1951 the cathodic protection system was revised. Protection is provided 62 tank bottoms, 30.2 miles of station lines and approximately 26 miles of trunk lines terminating at the station.

In the 10 years prior to protection, corrosion leaks in the tank farm lines averaged about 75 per year and 16 tank bottoms failed from soil corrosion. In the 10 years following installation of protection, no tank bottoms failed from soil corrosion and pit leaks in

tank farm lines decreased to less than three per year.

C. Cost of Protection

Investment in the Webster Station cathodic protection system amounts to \$24,000. Total annual operating expense, including depreciation, power and maintenance, is estimated at \$2600 per year. Even if protection of the lines was disregarded and all of this cost charged to the tanks, the unit cost of protection is very small. Installation cost of cathodic protection amounts to only \$390 per tank, total operating expense amounts to only \$42 per tank per year.

At the end of 1952, this company had under protection a total of 175 oil storage tanks at 18 stations. Installation cost of this protection averages about \$410 per tank. Total operating expense averages about \$62 per tank per year.

Considering \$12,800 as the investment represented by a large tank bottom, the \$410 per tank installation cost of cathodic protection amounts to only about 3 percent of the tank bottom investment. The \$62 per tank per year total annual operating expense of cathodic protection amounts to only about 1¼ percent of one repair job.

D. Conclusions

These data call for re-examination of the customary approach to protection of tank bottoms. Customarily, cathodic protection is applied selectively where, through tank bottom failures or corrosion of station piping, protection is known to be needed. With the cost of protection so small, the cost of bottom repair so large and the predictability of corrosion so unreliable, it appears that cathodic protection of *all* steel tank bottoms is justified except for those rare few at locations where it is *certain* that protection is *not* needed.

What are the overall economics of such a program? Humble Pipe Line Company has 336 unprotected steel bottoms of all sizes in the system. Protecting all of them would cost about \$138,000 for installation and about \$20,800 per year total annual operating expense. This installation cost has an indicated payout of about 1½ years; the total annual operating expense is only about 25 percent of the average annual cost of bottom repair.

These cost data indicate further that, for average conditions, coating the underside of tank bottoms or installing elaborate, expensive ground bed systems to improve current efficiency are difficult to justify if their purpose is to reduce the cost of protection.

External Pipe Coatings and Cathodic Protection

A. Development of Coating Practices

Before 1930, many, if not most, pipe lines were laid bare. Along about 1930 the facts of underground corrosion became more clearly understood and the principles and requirements of pipe coatings were being unravelled. Cathodic protection was a curiosity. During the 30's, prevention of pipe line corrosion was available only through coatings. It is understandable then that during the 30's and on into the 40's, strong

TABLE 3—Unit Costs of Tank Bottom Repair
(For 114-Foot Diameter Tanks)

a. Patching and Spot Welding.....	\$ 50 to \$ 2,000	
Plus Coating Upperside.....	\$ 3,000	
Total, Average.....		\$ 4,000
b. Installing Concrete Bottom.....		\$ 6,400
c. Installing New Steel Bottom.....	\$ 9,800	
Plus Coating Upperside.....	3,000	
Total.....		\$12,800

efforts were made to develop and apply holiday-free coatings.

It is now generally recognized that with the conventional enamel coatings absolutely holiday-free coating jobs are difficult and expensive, if not impossible, to obtain or to maintain. Even the best of these coatings carefully applied and rigorously inspected are not free from imperfections.

But today, now that cathodic protection has been developed, demonstrated and accepted, it no longer is necessary to rely solely on coatings for corrosion control. Cathodic protection has proved effective on bare pipe, on poorly-coated pipe and on well-coated pipe. The expression most frequently found in pipe line corrosion literature is: The most effective and economical pipe line protection is afforded by a combination of coating and cathodic protection.

Nevertheless in recent years there seems to be a trend in some areas at least toward coating structures and practices which still attempt to achieve holiday-free, perfect coatings. A number of recent pipe line construction contracts have required the completed lines to be traversed with a holiday locator and all coating holidays repaired by the contractors. A specification with similar intent requires the contractor to produce a coating job of a specified minimum electrical resistance. A proposed American Petroleum Institute pipe line construction code is in preparation at the present time. The committee was faced with the problem of whether or not to include, as requirements of good practice, using rock shield in rocky areas, or hauling in sufficient fine dirt or sand for four or six inches of padding below and above the pipe to protect the coatings. All of these practices can be expected to improve quality of coatings; they most certainly add considerably to construction costs. Are these practices and the costs they involve justified? What is the optimum combination of coating and cathodic protection?

B. Examination of 8-Inch Products Line Coatings

The first question that needs to be answered is "how good is a good coating job?" To answer this question, in 1948 Humble Pipe Line Company made a thorough examination of the best coated line it had in the ground, the 8-inch Baytown-Irving Products Line, laid two years earlier.

The southern 127 miles between Baytown and Hearne was yard coated with coal tar enamel reinforced with glass mat and wrapped with felt. All coated pipe was tested with a holiday detector at the coating yard and again over the ditch before lowering in. Inspection was rigorous.

The northern 148 miles from Hearne to Irving was coated with asphalt enamel reinforced with glass mat and wrapped with felt. The coating was applied over the ditch with line travelling equipment. In some sections the coated pipe was cradled directly in the ditch behind the coating machine and in others the coated pipe was lowered onto padded skids. An effort was made to secure a smooth soft ditch bottom throughout and in rocky areas the ditch was padded with sand. This section also was carefully inspected.

In the southern 127 miles, thirteen sections, each 5000 feet in length and each separated by approximately 45,000 feet, were traversed with a holiday locator. In the northern 148 miles, sixteen 5000-foot sections similarly spaced were traversed. Thus a 10 percent sample of the line uniformly distributed along the right-of-way was covered. All holiday indications were staked. More than half of the holidays located were uncovered and inspected.

In the southern portion a total of 62 holidays were located, an arithmetic average of five holidays per mile. Frequency of occurrence varied from none in one test section to twelve in another section. If the average is valid for the entire 127 miles, a total of approximately 635 holidays existed in the coating between Baytown and Hearne.

Major causes of holidays were mechanical damage incurred during construction and faulty application of field joint coatings. Mechanical construction damage included tool cuts, unrepaired skid damage, bulldozer blade gouges, scrap metal in the ditch bottom penetrating the coating, etc. More than half of the holidays inspected were of this variety.

Faulty field joint coating accounted for about 40 percent of the holidays inspected. Assuming that 40 percent of all holidays are poor field joints and that an average of five holidays per mile is valid, then only about one field joint of every 62 was faulty. This seems not at all excessive. The major cause of the faulty field joints has been corrected in subsequent construction.

Only two holidays chargeable to yard coating misapplication were found. No evidence of soil stress penetration or other deterioration of the coating was observed even though the line had been in service two years and much of the right-of-way was through tight clay soils in which coating deformation might have been expected.

In the northern portion, a total of 52 holidays were located, or about 3.5 holidays per mile. However, inspection of the coating revealed it to be generally penetrated by soil clods. These penetrations appeared to be a combined result of lowering hot coating directly into the ditch and of soil stress deformation during the two years of underground service. On an average, one to 10 penetrations per foot of pipe were found wherever the coating was inspected. Because of the many uniformly distributed penetrations the traverse located only major holidays. The number 3.5 holidays per mile is, therefore, meaningless. Inspection of the holidays disclosed them to be primarily the result of construction damage similar to those found in the southern portion.

What conclusions could be drawn from these examinations? Several conclusions and several more questions:

- 1) An excellent coating job may be far from perfect;
- 2) Cradling hot coating in the ditch caused innumerable penetrations even with a padded ditch bottom;
- 3) The particular asphalt coating used on the northern portion appears less resistant to soil stress penetration than the particular coal tar coating on the southern portion;

Among the questions raised are these:

- 1) Is jeeping logical? Can the expense and effort of searching every foot of pipe looking for a few isolated one-thousandth square inch pin holes be justified when in fact it is known the coatings will contain square inch and square foot holidays equivalent to thousands of pinholes? Is jeeping desirable? Since most of the holidays could have been observed visually was the attention of the inspector concentrated so much on the jeep that he could not see what was occurring in front of him and behind him? Was he placing undue reliance on an instrument operated by laborers? Would visual inspection entirely, with the jeep used only occasionally to spot check, result in better jobs?
- 2) How significant were the coating imperfections in view of the fact that cathodic protection of the line was planned? How much could cathodic protection costs have been reduced by reduction of holidays?

C. Cathodic Protection of 8-Inch Products Line

The northern 148 miles was protected with 22 groups of magnesium anodes in 1948. Eleven shorted casings totaling 1984 feet of bare 12-inch pipe consumed more than half of the output of the anodes. Despite the shorted casings and the "poor" condition of the coating, the protection cost only \$4300, equivalent to only \$29 per mile of protected pipe for an expected 10 years.

However, in the succeeding five years current requirements have increased slightly, output of some anode groups has decreased and additional casings have become shorted. In one area, 11 additional groups of anodes were installed in 1953 at a total cost of \$1760. In another area a rectifier was installed recently to protect 34 miles of pipe. Initial rectifier installation cost was \$1670, or \$49 per mile. Total annual operating expense is \$8.70 per mile of protected pipe per year.

The southern portion was protected along with

several other lines in the same right-of-way. Costs are difficult to prorate but about \$10 per mile installation cost and \$2 per mile per year total operating expense are liberal estimates.

What would it cost to traverse the southern portion of the line in its entirety and repair all holidays? A crew of three men could traverse an average of five miles per day at a cost of approximately \$100, or \$20 per mile. A repair crew of three men could be expected under average conditions to excavate, repair and backfill about five holidays per day at a cost of about \$100, or assuming an overall average of five holidays a mile, \$100 per mile. The total cost, therefore, of locating and repairing the holidays would approximate \$120 per mile. This does not seem excessive but cannot be justified on the basis of saving \$2 per year cathodic protection expense. Repair of all holidays in the northern portion would of course be impossible.

These data indicate that, from a dollars and cents standpoint, coating imperfections are not significant supplementary cathodic protection to compensate for the imperfections costs but a fraction of the cost of inspection alone.

D. Coating Practices and Costs vs Cathodic Protection Requirements and Costs

In Table 4 is summarized pertinent information on a member of Humble Company pipe lines for comparing coating practices and costs with cathodic protection requirements and costs.

The 8-inch Butane-Propane line, coated over the ditch during reconditioning in 1946 is fully protected with about the same amount of current (for all practical purposes) as the 8-inch Products Line which parallels it in the same right-of-way between Satsuma and Hearne.

TABLE 4
Comparison of Coating Practices and Costs With Cathodic Protection Current and Costs

Size Inches	Line	Length, Miles	Coating	Remarks	CATHODIC PROTECTION		
					Current Drained, amp./mi. ¹	Installation Cost	Total Operating Expense
8	Butane-Propane Satsuma-Hearne	88	Coal tar enamel & felt; over ditch reconditioning; 1946	Rectifiers installed 1952	0.088	About \$10/mi. ²	\$2-\$5/mi./yr. ²
8	Products Line Baytown-Hearne	127	Coal tar enamel, glass & felt; yard applied; 1946; rigorous inspection; total cost \$1510/mi.	Rectifiers installed 1952	0.034	About \$10/mi. ²	\$1-\$2/mi./yr. ²
8	Products Line Hearne-Irving	148	Asphalt enamel, glass & felt; over ditch; 1946; total cost \$1630/mi.	Magnesium anodes installed 1948; shorted casings took about 50% of current.	0.05 (In-1948) (Excludes shorted casings)	\$29/mi. (Includes shorted casings)	About \$6/mi./yr. (Includes shorted casings)
8	Same	....	Same	Rectifier installed 1952; protecting 34 miles.	1.2	\$49/mi.	\$8.70/mi./yr.
18	Kemper-Satsuma Western Portion	178	Coal tar enamel & felt; over ditch; 1950; not jeeped; no glass; no rock shield or ditch padding; coating cost \$2171/mi.; cost of omitted "extras": jeeping \$200/mi., glass \$400/mi., 120 mi. rock shield at \$238C/mi., total \$392,400.	Rectifiers installed 1952.	0.09 (Excludes Eckert Sta.)	\$37/mi. (Includes 65% of current taken by Eckert Sta.)	\$4.80/mi./yr. (Includes Eckert Station, 65%)
18	Kemper-Satsuma Eastern Portion	193	Coal tar enamel, glass & felt; yard applied; 1950; jeeped; coating cost \$3270/mi.	Rectifiers installed 1952.	0.14 (Excludes Warda Sta.)	\$47/mi. (Includes Warda 70%)	\$7.33/mi./yr. (Includes Warda Sta. 70%)
10 & 12	Skidmore-Ingleside	65	9 mi. coal tar enamel & felt; applied 1948; balance Safemco & felt, 1927.	Rectifiers installed 1951 in lieu of complete reconditioning.	40	\$1,000/mi.	\$197/mi./yr.

¹ Full protection, min. P/S—0.85v.

² Costs difficult to prorate. Parallel lines take most of rectifier output.

Neither the addition of glass reinforcement to the Products Line coating nor the other efforts expended to lay it holiday-free give it significant performance advantage over the Butane-Propane line coating. These "extras" cost at least \$200 per mile.

The Kemper-Satsuma 18-inch provides a basis for evaluating the probable worth of 100 percent jeeeping, glass reinforcement, rock shield, ditch padding and other "extras" calculated to improve performance of coatings. The western 178 miles was coated over the ditch with coal tar enamel and felt. The coating job was inspected visually, with a holiday detector used occasionally. The hot coating was lowered onto unpadded skids and the damage at each skid was repaired before the pipe was lowered into the ditch. Even though 120 miles was through rock ditch, no rock shield was used nor was the ditch padded. At \$200 per mile for jeeeping, \$400 for glass and \$2380 for rock shield, the extras would have increased the job cost by about \$392,400 or an overall average of about \$2200 per mile.

The line is now completely protected. Cost of installing cathodic protection amounted to \$37 per mile. Total operating expense of the protection amounts to only \$4.80 per mile per year even with one of the pump stations collecting 65 percent of the current.

The current required for protection may increase somewhat. It could double without substantial increase in cost because the rectifiers are operating considerably below their capacities. A four-fold increase in current demand would possibly double the protection costs, but can \$400 per mile be invested in glass or can \$2380 per mile be invested in rock shield to save \$5 or \$10 per mile per year cathodic protection expense? Just the interest on a \$200 per mile investment in jeeeping exceeds the total annual expense of cathodic protection.

The coating on the eastern portion of the 18-inch line was reinforced with glass and it was jeeeped in its entirety. It cost \$1100 per mile more than the coating on the western portion. Nevertheless, its performance is just about the same.

Protection costs of the Skidmore-Ingleside lines show that bare or practically bare pipe is expensive to protect, so that for minimum total cost, pipe coatings are needed.

E. Conclusions

There is a need for examining the relationship between coating practices and costs and cathodic protection requirements and costs. It is conceivable that for some rare cases cathodic protection may not be practicable and conclusions drawn from these data would not apply. The information here presented indicates that:

- 1) Even the best pipe line enamel coatings are not free from imperfections and require supplementary cathodic protection to fully protect the pipe.
- 2) The cost of cathodic protection on reasonably well-coated lines is so small that expense and efforts to secure more than reasonably good coating jobs are difficult to justify. Items of such expense include coating reinforcements, complete holiday detector inspection, rigid insistence on holiday-free construction, rock shield, ditch padding.

- 3) When supplemented with cathodic protection the maximum coating for general use appears to be 3/32-inch pipe line enamel wrapped with felt.
- 4) Lowering hot coating directly into the ditch creates many coating penetrations. However, this does not appear to increase cathodic protection costs significantly.
- 5) There is no significant difference between performance of coatings applied over-the-ditch and yard applied, as gaged by cathodic protection current and costs. Choice between the two methods should be based on cost, terrain, and weather conditions.
- 6) The industry is always alert for better materials and methods for improved coatings. However, improvements may be justified only if total pipe protection costs are reduced. Significant reductions in protection cost can be made only in the cost of the coatings themselves and the cost of application.

The data nowhere indicate that the coating inspector isn't warranted or that anything less than what is being paid for should be accepted. It does indicate that there is no justification for paying for materials and labor which give no more return than if the money itself was buried with the pipe.

DISCUSSION

Discussion by W. H. Stewart, Sun Pipe Line Co., Beaumont, Texas:

Mr. Sharpe's paper, in my opinion, fills a near void in our corrosion work with the NACE. Far too little has been published on this subject, if indeed much engineering has been applied to this phase of our work in the organization.

This brief discussion will be limited to the external corrosion control section of the paper since our own records and experiences are more complete in this category.

Mr. Sharpe's conclusions relating to "extras" such as rigid holiday inspection, the addition of reinforcing materials and special shielding is of particular interest since each can be expressed in dollars per mile. It can be easily demonstrated on any existing line that is cathodically protected just what one or more of the "extras" would amount to economically. A good example is a 20 mile section of 10-inch line in Southwest Texas laid in 1946. This section is electrically protected over what Mr. Sharpe terms "a reasonably good coating job." The present average annual power cost for this section that is protected by one rectifier at a pump station is \$43.60. By adding one of the "extras" to the original coating job, the additional cost for this 20 miles would have been \$3964.

Assuming that this "extra" would have cut the power requirements 50 percent (and there is some doubt on this) then it would take only about 180 years for this "extra" to pay out.

Mr. Sharpe is to be commended for his patience and thorough examination of a problem that so vitally concerns the pipe line industry.

Discussion by H. E. Waldrip, Gulf Oil Corp., Houston:

The author of this paper has done an excellent job

of presenting information desired by management, namely, the actual costs for different methods of installation and operation. In some cases actual field data are used and in others hypothetical cases are used. In the case of hypothetical data it must be assumed that the author's experience is such that the values used are practically as valid as if they were actually field data.

Wherever possible, the calculating of the data to a cost per foot per year basis makes comparisons very simple. It is of interest to note that in Tables 1 and 2, both cement lined pipe and lines using inhibitors appear very favorable. It is hoped that this paper will be the incentive to cause others to accumulate field data along the same lines. More such data are needed by industry to dictate future action. The various types of installations and the use of inhibitors and scrapers are frankly discussed.

The author makes a very good point in discussing coating practices and costs of cathodic protection. He does not advocate the haphazard application of pipe line coatings. Actually all coatings should be applied as well as man and machine can do so. He does emphasize, however, the lack of economic justification of so-called "extras," or the expensive inspection, testing, repairing of coatings and then allowing much more serious damage in placing the line in the ditch.

While the author does not specifically discuss the relative merits of an asphalt system versus a coal tar system, his data allow such a comparison. The southern 127 miles of an 8-inch line between Baytown and Hearne was coated with a glass reinforced coal tar enamel system, while the northern 148 miles of the same line, from Hearne to Irvin was coated with a glass-reinforced asphalt-enamel system. That portion of the line coated with the asphalt system suffered more construction damage than did the coal tar system. The cost of electrically protecting these two portions of the line is \$8.70 per mile per year for the northern half and \$2.00 per mile per year for the southern section.

The author's conclusions are very pointed and would bear sufficient study for the facts to be remembered.

Discussion by L. F. Sherer, Texas Pipe Line Co., Houston:

Mr. Sharpe opens his paper with the statement that a corrosion engineer's job is to reduce costs. This statement is not flattering to a corrosion engineer nor is it a complete statement. It would be more consistent to say that a corrosion engineer's duty is to design his part of a facility at the least cost consistent with good standard practice and future operating economy and to permit its maintenance at a minimum of expense to the owner. Aside from this statement, however, his approach to the problem is a practical one. More expensive and better materials may be used for such protection provided they show a reduction in over-all economy.

Three main topics are mentioned for consideration, but it is believed that a fourth and very important one was omitted; namely, external corrosion at a

pump station, principally an electric pump station. The trend toward electric powering of pump stations has been definite and innumerable problems have been encountered in providing corrosion protection to the conduit network and small piping in and about such a station.

Experience in general tends to support the statement that trunk lines which operate continuously at reasonably high velocities suffer negligible internal attack from sour crude. At the same time, however, when all factors are considered, it appears that the statement will hold more for those trunk lines which handle some sweet crudes along with sour crudes. There is experience to show that internal attack does occur on trunk lines which handle nothing but sour crude and operate at relatively high velocities. In addition and in both cases, it is evident that the frequency of scraper runs has a bearing on the corrosion rate.

The experience of those companies who have cathodically protected the underside of tank bottoms leaves no doubt as to the economies of such practice; however, consideration must also be given to equivalent protection of the upper or inside tank bottoms. This latter problem contributes appreciably to the deterioration of tank bottoms and tank maintenance; and while it is difficult to properly allocate the cost to the individual source of the deterioration, both must be given consideration.

It is believed that it might be well to stress the fact that coating of both sides of the tank bottom with proper insulating material will result in cutting the installation cost of cathodic protection in half and also in appreciably lengthening the life of tank bottoms. This has been definitely proved over many years of experience and justifies consideration.

Apparently the figures given by the author for the costs of laying cement-lined pipe are based upon the use of new pipe. Experience in the West Texas area covering many years and conditions has shown that it is quite practical and economical to recover unlined pipe, cull it, line with cement and relay. The costs are somewhat higher than shown, but the added life and service resulting therefrom prove the practice to be justified.

It is difficult to determine just what the author is trying to prove in his discussion under "External Pipe Coatings and Cathodic Protection," Section 3. The arguments are fallacious and will undoubtedly lead to grave misunderstandings by the inexperienced. Everyone familiar with the subject will admit that it is not practical to obtain a perfect coating but to even suggest that inspection be relaxed is most unprecedented and could lead only to irreparably poor coating jobs.

The author's arguments are based upon the premise that the coatings used on the two sections of line in question were equivalent in quality and durability and that the inspectors were equally conscientious. Certainly the materials were not of equal quality and the only other conclusion which can be drawn is that the inspection service left much to be desired. The resultant conclusions are subject to misinterpretation. Because of the differences in the

quality of the coating involved in the discussion, additional years of service will show far greater disparities than those indicated.

Every good pipe coating must have the following characteristics:

1. Low moisture absorption
2. Good electrical insulation
3. Insolubility in petroleum or its products
4. Resistance to soil pressure and deformations
5. Ease of application
6. Inertness to soil chemicals

A coating having the above qualities to the extent that is economically practical may be broadly said to be a durable and satisfactory coating, but only if properly applied. The quality of application is at least of equivalent importance to the quality of the material and to the durability of the finished job. Cathodic protection must be considered as a necessary supplement to line protection and not a remedy or adjunct.

It can be shown, however, that cathodic protection will prove an effective adjunct to a poor coating job and prolong the life of the line so coated. To that extent only, it will prove economical, but the over-all picture will not be one of economy. There is no substitute for quality of materials and application and this cannot be stressed too strongly. Quality of materials and application is any engineer's best answer to economy on any problem.

The author has done an excellent job in calling industry's attention to the problems he has discussed. Factual data are invaluable in the analysis of any economic problem and the development and availability of such information should be encouraged.

Reply by L. G. Sharpe:

Mr. Scherer is certainly correct in calling attention to the importance of external corrosion at electric pump stations. Because the problem here involves standard electrical installation practices—especially grounding—progress has been relatively slow. The problem warrants thorough joint investigation by the most capable corrosion engineers and electrical engineers.

One company has coated the underside of a large number of its storage tank bottoms. After construction of the bottom and lower ring, it is jacked up and the bottom is cleaned, primed and coated with a bituminous coating. For a 55,000 bbl. tank (114-foot dia.) the coating reportedly costs about \$1500: \$1000 for contract application, \$500 for materials.¹ This investment in coating reduces the installation cost of cathodic protection to about \$250 per tank and the annual operating expense of cathodic protection to about \$25 per tank per year. With but few exceptions, to coat or not to coat seems to depend upon whether or not an investment of \$1500 is justified by the saving of \$160 initial cost and of \$37 per year operating expense of cathodic protection.

The figures for concrete-lined pipe are for 2nd class pipe as shown in Table 1 and 3rd class pipe as shown in Table 2. These figures, briefly described under "1 C 3. Concrete-Lined Steel Pipe," were taken from recent field experience in West Texas.

Mr. Scherer is one of the small group of engineers to whom the industry is indebted for the development of our modern pipeline coatings. The thought of returning to the coating practices of only two decades ago is as abhorrent to the author as it is to Mr. Scherer. The intent of the author is well stated in the third paragraph of H. E. Waldrip's discussion and in the second paragraph of Scott P. Ewing's discussion.

Reference

1. Private Communication.

Discussion and Comments by N. K. Senatoroff, Southern Counties Gas Company, Los Angeles:

I am pleased to have been asked to discuss and present additional data on the subject, "Economic Consideration in Pipeline Corrosion Control," which was so ably presented in a paper under the same title at the Tenth Annual Conference of the National Association of Corrosion Engineers in Kansas City, March, 1954.

Because most of my actual experience has been with an application of cathodic protection for soil corrosion control of natural gas pipelines, the discussion and comments will be confined to this type of cathodic protection application.

In the past, many enlightening discussions and papers have been published which dealt with the various economic aspects of cathodic protection. Some were slanted towards overestimating the actual costs of cathodic protection and others, underestimating them. As a result, one will find considerable variation in the interpretation of the final conclusion as to the "actual installed" cost of the cathodic protection in relation to the overall cost of corrosion protection. Especially so on installations in which in part at least the corrosion control measures are underwritten by the protective coating applied to the substructure.

The reason for an existence of such divergent interpretations of the findings in such studies is quite natural. In most instances, the authors would be studying a case history of a specific application of cathodic protection and bring into the "economics" study, their company's policies in stressing concept of the relative importance of the various items which enter into the capital costs and annual operating costs of cathodic protection per mile per year.

This explanation, more than anything else, would serve to illustrate the reason for a considerable discrepancy between the figures of cathodic protection costs of the Southern Counties Gas Company and such costs given in the paper. The "capital" costs in Southern Counties Gas Company are comprised of the following items:

- Cost of cathodic stations including the rectifier, the anode grounds, the power lines and, occasionally, the land.
- Cost of electrical test points at approximately 2,000-foot intervals along the pipeline for potential surveys.
- Cost of insulating flanges, insulating materials for valves, pipe supports, bridge crossings, etc.

In the case of 212 miles of 30-inch OD well coated and carefully inspected line, with a planned installation program for the application of cathodic protec-

tion at the time of construction, the total cost for cathodic protection amounted to \$230 per mile of which \$77 per mile constituted the cost of the cathodic stations. In the case of 34 miles of 16-inch OD very well coated and inspected line, also with a planned installation program, the total cost for cathodic protection was equal to \$166 per mile, of which the cost of the magnesium anodes accounted for \$27 per mile.

In the light of such expenditures the "annual fixed charges," based on 10 years' life of the station and amounting to approximately 35 percent of the capital costs, are \$80.50 and \$58.10 per mile per year, respectively.

These "annual fixed charges" are made up of the maintenance costs, interests, depreciations, taxes, etc.

Pipe Coating Quality

The effect of the pipe coating quality on the "capital" costs and the "annual fixed charges" is very forcefully brought out by the following figures compiled for the case history of a 56-mile, 12 $\frac{3}{4}$ -inch OD line. This line was also well coated but not inspected and no planned program for cathodic protection installation at the time of its construction was considered.

The total capital cost for cathodic protection application subsequent to completion of the line amounted to \$301 per mile, as compared to \$230 per mile reported on the 30-inch line. Of this investment the \$148 per mile constituted the cost of the stations against the \$77 per mile stated in the case of the 30-inch OD line.

The annual costs for eight cathodic protection stations needed to protect approximately 28.1 miles of 8-inch and 12-inch of "inadequately coated and inspected lines" were reported and published by the Pacific Gas and Electric Company to be of the same order of magnitude.

Their "annual costs" ranged between \$119.27 and \$157 per mile on the section of 8-inch line, and \$80 per mile for the 12-inch portion. The "capital" costs per station amounted to approximately \$250 per mile.

Viewing the costs established in our Company and other utilities on the Pacific Coast, one arrives at the following conclusion:

- Planned installation of cathodic protection facilities at the time of construction of new well coated mains lowers capital costs.
- Annual fixed charges for cathodic protection are also lowered.
- Capital costs for installation of cathodic protection facilities on existing coated mains after the completion of the line are high.
- Good coating and careful inspection of the coating at the time of pipe line construction result in considerable savings in capital costs as well as in the annual fixed charges.

In our definition of a reasonably well coated line, I am also permitting myself to differ with the author somewhat. In studying the conclusions in the paper, it appears to me that by "reasonably well coated" line, the author means a well coated line whose coating was reasonably well damaged during installation. To me, the statement that "major causes of holidays were mechanical damage incurred during construc-

tion and faulty application of field joint coatings. Mechanical construction damage included tool cuts, unrepaired skid damage, bulldozer blade gouges, scrap metal in the ditch bottom penetrating the coating, etc. More than one-half of the holidays inspected were of this variety . . ." confirms my interpretations of the coating quality.

How would a customer define the quality of an electrical installation if the electrician he retained for an important transcontinental cable installation permitted his men to handle the tools and equipment with an equal carelessness?

In the application of protective coatings to the pipelines one could never go wrong in emphasizing the absolute necessity for careful, thorough and painstaking work if he wishes to obtain satisfactory return on the money invested in the coating. If the importance of coating quality is stressed by giving some instructions to the men handling it, there would not be any excuse for the slipshod, careless construction methods that characterize the pipe coating work.

If such a training program for the coating crews is included in the planned and carefully scheduled construction program, the additional expense, directly chargeable to this phase of the work, would be negligible in relation to the direct savings in cost which will be reflected during the long years of service of the pipe line.

In a paper, "Economic Factors Bearing on Application of Cathodic Protection," by D. B. Good (Cathodic Protection—a Symposium by the Electrochemical Society and the National Association of Corrosion Engineers, 1949), the author gives a chart showing some relative current requirements for so-called "good coating jobs" and "poor coating jobs." It is interesting to note that "for the comparisons made, the ratio between the extreme is 150." Certainly, efficient and economical over-all protection favors continued and extended efforts to obtain "good coating jobs."

In conclusion I want to congratulate Mr. Sharpe for an excellent, thought provoking, constructive contribution to the collection of valuable papers which comprise the library of the National Association of Corrosion Engineers.

Reply by L. G. Sharpe:

Mr. Senatoroff is to be thanked for his extensive cost data. It is unfortunate that the current drainage for each of the cases cited was not given, for coatings can be evaluated and compared only on the basis of their conductances. The descriptive terms, "well-coated, reasonably well-coated, poorly-coated, carefully inspected, reasonably well-damaged," obviously mean different things to different people. Frequently they are expressions of opinion rather than statements of known conditions. Mr. Senatoroff's attempt to show the effect of coating quality on cathodic protection costs by comparing a 56-mile 12-inch line with a 212-mile 30-inch line is lost because no information is given on the coatings other than that the 30-inch was "well-coated and carefully inspected" and the 12-inch was "well-coated but not inspected."

I am sure that a general indictment of authors of cathodic protection papers for intellectual dishonesty was not intended. Differences in accounting practices, in engineering procedures and in type and method of installation make differences in costs inevitable. The costs given in the paper were taken from accounting department records. Installation costs include all material, freight, warehousing overhead, right-of-way, installation labor and equipment costs and overhead and engineering charges. The annual operating expense includes power, depreciation at ICC rates, maintenance and servicing. Either Mr. Senatoroff's unit cathodic protection costs are considerably higher, or the pipelines mentioned in the discussion require greater current densities for protection and, therefore, have coatings of greater conductance than those described in the paper.

Discussion by Guy Corfield, Southern California Gas Company, Los Angeles:

It certainly appears that the economics of pipe coating vs. cathodic protection, particularly when they are used together for protection against soil corrosion are very important and should be examined exhaustively.

We have for some time on our important pipe lines, followed the general plan of applying the best coating reasonably possible and supplementing it with cathodic protection. This "best coating reasonably possible" has been a substantial application of materials plus jump spark and Pearson holiday detection and the repair of such holidays to the extent possible. It has been relatively expensive but has, in recent applications, been relatively successful if success is measured by its requiring only a small amount of cathodic protective current and we should probably re-examine this approach. We have heretofore had the background feeling that, no matter how hard we tried to put on a good coating, the net result will be only fair because of the unavoidable mechanical damage during installation, or relatively rapid deterioration through water absorption, penetration by stones and earth clods, etc. We are now becoming able to build up some history and experience on this service life with respect to continued electric resistance of various coatings.

There might be some conditions under which you should perhaps apply the very best coating you can even though the direct economics would seem to indicate that you were wasting money. I have reference to circumstances where there are practical limitations to the amount of cathodic protective current you can apply, even though the direct cost of such current is not out of line. For instance, we have several large lines, in most instances 30 inches in diameter, which traverse and in general form a distributing loop through our metropolitan Los Angeles area. It would be very difficult to cathodically protect these lines with large quantities of current, not only because of the problems of "interference" of such current with the many other paralleling and intersecting substructures, but also because of the difficulty of establishing anode sites in heavily built-up

areas. We have in such instances, by very careful coating application, been able to install 30-inch lines 10 or 15 miles in length, which can be protected from one end with 15 or 10 amperes or less. In an area such as ours in Southern California, which is developing and building up rapidly and continuously, we are having increasing difficulty in finding anode sites, or keeping them because of the increasing value of the land where they are installed and this together with the accompanying build-up in density of other underground structures seems to indicate that at least in populated areas we should lean toward the practice of depending on cathodic protection to plug the unavoidable holes in a good coating rather than depending on cathodic protection for the major share of the protection of the pipe. In suburban areas and cross-country pipelines the situation would seem to be quite different.

Discussion by R. P. Howell, Standard Oil Co. of California, San Francisco

This paper is a good presentation of the important economic aspects of corrosion control. It presents a much-needed emphasis of the fact that perfect or nearly perfect coatings are not necessarily the most economical means of controlling corrosion. Although I have not attempted the detailed economic analysis presented by the author, his conclusions on the overall economics of pipe line corrosion control correspond very closely with the practices my company has followed for a number of years.

One additional point might be made with respect to corrosion control of pipe lines in built-up areas. Where lines pass through city streets or residential areas, it may be worth while to go beyond the theoretically economical point and provide the best possible coating to insure against leaks that will be hazardous, costly, and damaging to public relations. A further advantage of a coating of highest quality in such areas is that the current required for supplemental cathodic protection will be so low that few problems of interference currents with utility lines would be expected.

Discussion by Charles L. Woody, United Gas Corp., Houston:

Mr. Sharpe is to be complimented on a thought-provoking paper. In general we are inclined to agree with his conclusions 100 percent, but in this it is pointed out that each job should be considered on its own merits. Consideration should be given to the terrain traversed, estimated operational life of the pipe, material to be handled by the pipe line or tank and other factors that may be peculiar to the job.

There is no doubt that external corrosion of underground steel surfaces can be entirely eliminated in practically all cases by the proper application of cathodic protection, but the application of cathodic protection alone may be expensive.

Experience in certain areas has indicated that a practical coating, when cathodic protection is applied, will pay for itself in approximately five years in saving of cathodic protection costs. If cathodic

protection is not applied the coating would be expected to pay itself out in reduction of leaks alone over a period of time. It is doubtful that a coating can be applied under field conditions that will not have holidays either at the time of installation or that will develop later due to either coating failure or mechanical damage to the coating. Under normal soil conditions it would be expected that leaks would occur at some future date. The actual economic value of cathodic protection in addition to coating would depend upon the cost of repairing or replacing the pipe. From an engineering point of view it is hard to justify any type coating without spending the small additional insurance cost of cathodic protection. In many instances, even in the most corrosive soil conditions, this will be less than 1 percent of the installed pipe cost. Or, if we take the view of the cathodic protection engineer, there is no doubt but that the life of the original pipe could be prolonged indefinitely by the use of cathodic protection alone.

An economic analysis may prove that the life of bare steel pipe would be sufficiently long to make the application of the coating or cathodic protection unjustified. Even this approach may be economically sound where the useful life of the pipe is short and salvage costs of such magnitude to make the salvage of the pipe uneconomical or failure from uncontrollable internal corrosion is to be expected. In every case consideration must be given to many factors to determine the economics of corrosion control and the extent to which corrosion control should go.

On a particular piping installation that was installed in 1946, it was a known fact that many pin holes and coating faults existed. In view of the very poor condition of the coating, cathodic protection was installed using magnesium anodes. The original current requirement was approximately 0.175 amperes per mile. Since this initial installation the original coating as indicated by current requirements has improved 100 percent, or another way of expressing it, the present cost of cathodic protection is approximately 50 percent per year less than the cost during the first few years of operation. In this case there is little doubt but that any money spent on repairing the numerous known small holidays and the use of the more elaborate methods of determining coating faults and repairing pin holes would have been an unnecessary expenditure. Of course it is realized that in the case of poor coating any failure of cathodic protection due to improper application or effects that may be experienced in electrically isolated soil, penetration of the pipe could have resulted in rather short order and the economics of the poor coating could have been entirely reversed.

It must be realized that the engineers who advocate as perfect a coating as practical certainly have points in their favor, in view of the fact that the practical application of cathodic protection may not result in 100 percent protection and one or more leaks or line failures could far offset the additional cost of a practical perfect coating. Despite the fact that corrosion engineers do obtain astounding results from both a cost consideration and corrosion control, there is still the insurance factor that should be considered

when considering the use of jeeps, Pearson detectors, and other methods of locating and repairing coating holidays.

Reply by L. G. Sharpe:

Messrs. Corfield, Howell and Woody bring out an important point: Good engineering and sound economics may dictate a different combination of coating and cathodic protection in critical congested areas than might be used elsewhere.

Discussion by Leonard C. Hill, Kansas-Nebraska Natural Gas Co., Inc., Hastings, Neb.:

Regarding external pipe coatings and cathodic protection, Mr. Sharpe's paper indicates some straight thinking and an approach to good economics. We fully agree with his conclusion as drawn.

We feel that coatings and cathodic protection go together. If it were possible to get a perfectly holiday free coating, it would be impossible to maintain it as such for long without great expense. A reasonably good coating supplemented by cathodic protection will provide desired results with greatly reduced construction costs and low maintenance and operating expense. The cost comparisons presented in Table 4 concur favorably with our own experience.

We generally use line travel procedure on long cross country lines and mill coated pipe in short lines, gathering lines, distribution and maintenance repairs and apply cathodic protection immediately after construction is completed.

On cross country pipe line construction, we apply $\frac{3}{32}$ -inch coal tar enamel, a wrap of glass mat and a wrap of kraft paper by line travel machine and lower the pipe into the ditch directly behind the machine. There being little rock in our country and a mellow sandy clay soil, satisfactory ditch conditioning is accomplished by using ditch drags on the ditching machine. Spot jeeping is used primarily to determine conditions that need correction. We believe in visual inspection at the machine. Primer conditions, coating thickness, glass penetration, coating bond, continuity and machine travel are important and can be overlooked if a great deal of attention is given to a jeep.

This procedure makes for lower construction costs and no significant difference in cathodic protection costs. We do maintain 1.00 volt P/S potential on coated lines. We have applied cathodic protection since early 1938 and have used several coating procedures with similar results and only three corrosion leaks in over 1400 miles of coated and protected lines. These leaks occurred in a two-mile section of thin and poorly bonded coating with interrupted treatment in a stray current area.

Discussion by N. P. Peifer, Manufacturers Light and Heat Co., Pittsburgh:

I agree with the author that the use of a holiday detector is not necessary or required as an inspection method after the coated line has been installed. The cost of excavating and repairing the faults will often pay for the cathodic protection installation. If the company installing the pipe line has a good coating inspector on the job he will find and repair 80 per-

cent or more of the damage before the line is laid in the ditch. If the owner of the line will not install cathodic protection then the holiday detector could be used to secure a coating without faults, if that is possible, but the tests would have to be made at least once a year and the faults repaired. The cost of such a procedure at the end of ten to twenty years would probably exceed the cost of a new line.

I believe that the use of a jeep is necessary when a coating is being installed and when the pipe is being laid in the ditch.

Some of the troubles that cause coating failure cannot be seen by the best of coating inspectors. On one of our installations an excess of moisture was present in the primer. This was not apparent on the finished priming job and only showed up when the coating was jeeped. When the coating machine is first started up there are often particles of coke applied with the enamel. These can only be found by the use of the jeep. After the job has been going for about an hour it is possible to discontinue the use of the jeep if a good coating inspector is on the job.

Rock shield is a definite part of every coating job in the part of the country in which we operate. In many instances the pipe will be laid through solid rock for thousands of feet. If a coated pipe were installed without the protection of rock shield through these areas there would be numerous places where the coating had been scraped off. The rain water laying in these depressions would cause the metal to rust and eventually a penetration would occur. Since there is no soil present cathodic protection currents could not reach these faults and protect the pipe.

In a congested area where there are numerous pipe lines it has been found that the better the coating job the less current is required for cathodic protection and as a result of this the cathodic interference is reduced to a negligible quantity. It is not uncommon for a cathodically protected line to cross as many as 50 to 100 foreign lines in a distance of 50 miles or more. You can realize what a good coating means under these conditions.

Discussion by John R. Ligon, Sinclair Pipe Line Co., Fort Worth:

With reference to Mr. Sharpe's paper on "Economic Considerations in Pipe Line Corrosion Control" and speaking for the Texas Division of the Sinclair Pipe Line Company, the following comments are made.

Part No. 1—*Internal Corrosion in Sour Crude Oil Pipe Lines*

Inasmuch as all of the sour crude oil handled by the Sinclair Pipe Line Company in Texas and New Mexico is gathered and transported by joint ownership pipe lines, all of which are operated by the other participating companies, no comment will be made on this part of Mr. Sharpe's paper due to the lack of actual experience.

Part No. 2—*External Corrosion of Storage Tank Bottoms*

This Company is in full accord that cathodic protection should be provided for storage tanks and station

pipings. Installation of rectifiers on pipe line stations was stated by Sinclair Pipe Line Company in July 1940 and at the present time only a few stations in the state of Texas with tankage are not protected by rectifiers.

Part No. 3—*External Corrosion of Buried Pipe Lines*

Complete agreement with the six conclusions drawn by Mr. Sharpe in this part of his paper can be substantiated by the following data:

In 1927 the Prairie Pipe Line Company (now Sinclair Pipe Line Company) laid an 8-inch line in the Texas Panhandle coated with coal tar and felt. In 1942 this line was taken up in joints 40 feet in length and hauled to the Gulf Coast on trucks. It was then laid, after only the patching of the field joints, between Corpus Christi and Damon, Texas, with the exception of creek and river crossings through which pipe with new coating was used. Between 1947 and 1949 cathodic protection was applied to this 160 miles of 8-inch with a current requirement of less than 1½ amperes per mile. At the present time approximately only 2.6 amperes per mile is required.

Also noted with some interest is that Humble Pipe Line Company is having trouble with shorted casings. Is it possible that more economy could be realized by yard coating all casings rather than spending money on casing insulators and applying cathodic protection to shorted casings? However, it must be realized that the casings would have to be plugged water tight at the ends in order to make this feasible. It is also obvious that a certain amount of coating would probably be lost while installing the casing. However, this could be minimized by either boring a slightly larger hole or protecting the casing with wooden strips during the installation operation.

Reply by L. G. Sharpe:

The general practice now is to coat all casings and to install insulating pipe supports and end sealers. The pipe supports pay off in reduced time and effort to pull the pipe into the casing.

Discussion by Scott P. Ewing, Carter Oil Co., Tulsa:

It is believed that Mr. Sharpe's paper is a very important contribution because it shows with actual cost data that there is a way to arrive at an approximate economic balance between the cost of coatings and the cost of cathodic protection. In the examples of coated lines which he gives, a little less expenditure on the coating gives a lower total cost of corrosion control.

For many years there has been a continuous effort to put more material of the right kind on the pipe in as nearly a continuous layer as possible. This effort has been well worth while and I do not think it is the intent of the author to recommend a return to the good old days when a pipe coating was defined as something black, that smelled like tar, which was poured on the pipe after it was lowered into the trench. In fact I think that even today there are many lines where more expenditure for coating at the time of construction would have resulted in lower total operating costs.

It might also be pointed out that the lines dis-

cussed are in a region of rather low soil resistivity which is favorable to the use of cathodic protection. Where soil resistivities are higher, as in most of the east and south it might be more economical to use a somewhat better coating, rather than depend too much on cathodic protection. But neither cathodic protection alone or the coating alone is likely to be the economic solution on any pipe line.

The problem of controlling internal corrosion has not reached the stage where economic balances can be set up. Some of the methods now used may become obsolete as has been the case in external corrosion. Inhibitors are used down the well and in products lines, that is, at the ends of the long route from the formation to the automobile gas tank. Perhaps in time inhibitors will be used all the way and even in the salt water injection and disposal systems. More will have to be learned so that combinations of mutually compatible methods will supplement each other and completely protect all the equipment. There must be a way to use the right inhibitors so they will not be absorbed on filters and cement linings, the right coatings so they will supplement and not destroy the inhibitors, along with cathodic protection in large vessels and thus protect all the internal surfaces from the bottom of the well to the customers' gas tanks at reasonable cost.

Complete studies of all costs involved on the entire system, as was done in this paper, will be helpful in arriving at the ultimate solution.

Reply by L. G. Sharpe:

As implied by Dr. Ewing, cathodic protection is simpler to apply and cost is less in low resistance soils than in high resistance soils. The lines discussed in the paper are in soils of from less than 500 ohm-cm. to more than 100,000 ohm-cm. The southern half of the 8-inch products line is mostly in low resistance soil; the western portion of the 18-inch Kemper-Satsuma Line is mostly in very high resistance soils. The experience with the latter shows that "reasonably well-coated" pipe is indicated on the basis of both engineering and economics for high resistance soils the same as it is for low resistance soils. Never-

theless, Dr. Ewing make an important point, contrary to previous practice: Coating needs are greater in areas of high resistance soils than they are in areas of low resistance soils.

The problem of internal corrosion in sour crude oil systems is more than 25 years old. The corrosion control methods discussed have been in use now for from 5 to 20 years. Corrosion and cost data are voluminous. Agreed that improvements in these methods will be made and that methods yet unconceived will be developed, should the operators wait for these developments to occur while they replace their pipe every 1½ to 5 years or should they take advantage of the methods and economies available to them now?

References

1. Minutes and Reports, Div. of Transportation, API, 28th Annual Meeting, Nov. 1948, page E-19. See also: W. L. Nelson, *Oil & Gas J.*, **51**, 145 (1953) May 4.
2. Minutes and Reports, Div. of Transportation, API, 31st Annual Meeting, Nov. 1951, page E-22. Minutes and Reports, Div. of Transportation, API, 32nd Annual Meeting, Nov. 1952, page E-23, E-24.
3. L. R. Sheppard, *Proc. API*, **28** (V), 27 (1948).
4. Milton B. Grove, Internal Coating of Pipe in Place. *Corrosion*, **10**, No. 5, 142-146 (1954) May. J. K. Alfred, *Oil & Gas J.*, **49**, No. 28, 266 (1952) Nov. 16. John C. Watts, Internally Coating Pipe Lines in Place With Plastics. *Corrosion*, **11**, No. 5 (1955) May.
5. R. A. Brannon, *Petro. Eng.*, **14**, 52 (1942) Sept.

Bibliography

- Sour Crude Corrosion:
L. R. Sheppard, *Corrosion*, **6**, 27 (1950) Jan.
- Plastic Pipe:
G. Miller, *World Oil*, **135**, No. 3, 258 (1952) Aug.
J. F. Fugazzi, *Gas Age*, **111**, No. 10, 54 (1953) May 7.
- Aluminum Pipe:
Almont Ellis, *Corrosion*, **8**, 289 (1952) Aug.
- Tank Bottom Protection:
Donald Bond, *Petro. Eng.*, **12**, 100 (1940) March.
L. A. Snyder, *Gas*, **29**, 44 (1952) Jan.
J. R. James & R. L. Featherly, *Petro. Tech.*, (1947) May.
S. P. Ewing & J. S. Hutchinson, *Corrosion*, **9**, 221 (1953) July.
- Pipe Coating & Cathodic Protection Cost Data:
G. R. Olson and H. V. Beezley, *Corrosion*, **5**, 249 (1949) Aug.
S. A. Wright, *Gas*, **22**, 38 (1945) May.
D. C. Glass, *Corrosion*, **7**, 322 (1951) Oct.
A. C. Nelson, *Corrosion*, **4**, 123 (1948) Mar.

High Temperature Corrosion Data

*A Compilation by Technical Unit Committee T-5B On High Temperature Corrosion**

Introduction

THE NATIONAL ASSOCIATION of Corrosion Engineers has assigned to Unit Committee T-5B the study of the behavior of both metallic and non-metallic materials at high temperatures. These arbitrarily are considered to be temperatures above 400 F. As its first project the committee undertook a compilation of high temperature corrosion data. The results of this compilation are presented in the accompanying tables.

Sources of Data

By far the greatest amount of data compiled for the tables was obtained from Shell Development Company Engineering Report No. 327, "Corrosion Data Survey" (1948). The committee is indebted to G. A. Nelson, who compiled Engineering Report 327. The committee also appreciates the permission granted by the Shell Development Company to use the data from its report. Other sources of data were:

The International Nickel Company.

American Society for Testing Materials, Special Technical Publication, No. 68, 1946, pp. 129-152.

Pittsburgh International Conference on Surface Reactions, 1948.

Zh. Prikladnoy Khimii, Vol. 21, No. 1, 1948, pp. 35-41.

NACE Unit Committee T-6K on Corrosion Resistant construction with masonry and allied materials.

Table Headings

An explanation of the various headings in Table 2 follows:

Materials—The nominal composition of these materials is given in Table 1. Unless otherwise specified all of the metallic materials must be assumed to be in the annealed condition.

* John J. Halbig, Armco Steel Corp., Middletown, Ohio, Chairman.

Abstract

The behavior of 31 materials ranging from cast iron to lead, including a number of stainless steels and high alloys subjected to temperatures over 400 F is tabulated. Data are derived from Shell Development Company's Corrosion Data Survey (1948), among other sources. Corrosion rates are indicated as low, moderate or high versus specific temperatures. Additional data are solicited by the compiling committee.

Concentrations of Corrodents—Concentrations less than 100 refer to aqueous solutions. Listings of 100 refer to anhydrous conditions.

Explanation of Table 2

The corrosion data tables apply only to temperatures of 400 F and above. In many cases the lowest temperature for which data are available is above 400 F.

Rates at the listed temperatures are indicated as low, moderate or high in a given medium. The following symbols have been used to denote corrosion rates:

- ‡ low corrosion rates
- § moderate corrosion rates
- ✕ high corrosion rates

For example, the table lists 5 Cr in sulfur containing oils as follows:

500 ‡
600 §
700 ✕
800 §
900 ‡

This listing is interpreted as follows:

At 500 F the 5 Cr steel has a "low" corrosion rate.

As the temperature increases to 600 F, the corrosion rate becomes "intermediate," and as the temperature increases to 700 F the corrosion rate becomes "high." With further increases in temperature the corrosion rate decreases. Thus, at 800 F the rate is "intermediate" and at 900 F the rate is "low."

In hydrogen chloride (anhydrous), Inconel is listed as follows:

800 $\frac{1}{2}$
900 $\frac{3}{8}$

This listing means that from 400 to 800 F, the corrosion rate of Inconel is "low." At 900 F Inconel has a "moderate" corrosion rate.

Thus, the corrosion rate for the lowest temperature given for a particular material in a particular environment is its corrosion rate from 400 F to the temperature indicated. In other words, the information in the tables may be extrapolated down to 400 F. The information may be extrapolated to higher temperatures only when a corrosion rate in the table is rated "high."

Uses and Limitations of the Data

The user of these data is warned that they may not constitute a solution to a particular corrosion problem. This is so because the corrosion of a material of construction may be markedly influenced by such variables as welding, stress relief after welding, stress applied to the material during service, presence of crevices, such as lapped joints, presence of minor impurities in the corrodent, agitation and aeration of the corrodent and other variables that are not included in the data tables. Therefore these tables should be used only as a guide for the selection of materials of construction.

The committee strongly advises the user to select a group of materials that appears best and then conduct tests under service conditions.

Additional Data

The committee recognizes that these data tables are not complete and that much additional data exists, especially in an unpublished form. Therefore, the committee asks that users submit any additional data that should be included. Proper credit will be given where desired.

TABLE 1—Analyses of Various Metals and Alloys Listed

	C	Fe	Cr	Ni	Cu	Si	Mo	Zn	Mn	Other
Steel.....	0.10-30	Bal.	.....	.....	.....	.10 ²	.....	.....	.50-.80	.....
Cast Iron.....	2.75-3.50	Bal.	.....	.....	.....	1.90-2.25	.....	.....	.50-.80	.....
Ni-Resist—Type I.....	3.0 ¹	Bal.	1.75-2.5	13.5-17.5	5.5-7.5	1.0-2.5	.....	.....	1.0-1.5	.....
Copper.....	.....	.....	.....	.....	99.9	.....	.....	.....	.....	.....
Tin Bronze.....	.....	.....	.....	.....	88.0	.....	.....	2.0	.....	10.0 Sn
Aluminum Bronze.....	.....	.....	.....	.....	95.0	.....	.....	.....	.....	5.0 Al
Red Brass.....	.....	.....	.....	.....	85.0	.....	.....	15.0	.....	.....
Yellow Brass.....	.....	.....	.....	.....	60.0-70.0	.....	.....	30.0-40.0	.....	.....
Admiralty.....	.....	0.06 ¹	.....	.....	70.0-73.0	.....	.....	Bal.	.....	0.9-1.2 Sn
Silicon Bronze.....	.....	.....	.....	.....	97.0	3.0	.....	.....	.....	.....
4-6 Cr-Mo Steel.....	0.15 ¹	Bal.	4.0-6.0	.....	.....	1.0 ¹	0.5	.....	1.0 ¹	.....
Type 410 S.S. (12 Cr).....	0.15 ¹	Bal.	11.50-13.0	.....	.....	1.0 ¹	.....	.....	1.0 ¹	.....
Type 430 S.S. (17 Cr).....	0.12 ¹	Bal.	14.0-18.0	.....	.....	1.0 ¹	.....	.....	1.0 ¹	.....
Type 446 S.S. (27 Cr).....	0.35 ¹	Bal.	23.0-27.0	.....	.....	1.0 ¹	.....	.....	1.5 ¹	.....
Type 304 S.S. (18 Cr—8 Ni).....	0.08 ¹	Bal.	18.0-20.0	8.0-11.0	.....	1.0 ¹	.....	.....	2.0 ¹	.....
Type 316 S.S. (18-12-2 Mo).....	0.10 ¹	Bal.	16.0-18.0	10.0-14.0	.....	1.0 ¹	2.0-3.0	.....	2.0 ¹	.....
Type 317 S.S. (18-12-3 Mo).....	0.10 ¹	Bal.	18.0-20.0	11.0-14.0	.....	1.0 ¹	3.0-4.0	.....	2.0 ¹	.....
Type 309 S.S. (25 Cr—12 Ni).....	0.20 ¹	Bal.	22.0-24.0	12.0-15.0	.....	1.0 ¹	.....	.....	2.0 ¹	.....
Type 310 S.S. (25 Cr—20 Ni).....	0.25 ¹	Bal.	24.0-26.0	19.0-22.0	.....	1.5 ¹	.....	.....	2.0 ¹	.....
Type 304 S.S. (18 Cr—8 Ni).....	0.10 ¹	Bal.	21.0	.....	.....	.....	.....	.....	.....	4.0 Al
Monel.....	0.15 ¹	1.4	.....	67.0	30.0	0.1 ¹	.....	.....	1.0	.....
Nickel.....	0.05 ¹	0.15	.....	99.4	0.10	0.05	.....	.....	0.20	.....
Inconel.....	0.08 ¹	7.0	15.0	77.0	0.20	0.25	.....	.....	0.25	.....
Hastelloy A.....	0.10 ¹	22.0	.....	55.0-60.0	.....	.....	22.0	.....	.....	.....
Hastelloy B.....	0.12 ¹	4.0-7.0	.....	60.0-65.0	.....	.....	26.0-30.0	.....	.....	.....
Hastelloy C.....	0.15 ¹	4.0-7.0	13.0-16.0	55.0-60.0	.....	.....	15.0-19.0	.....	.....	3.5-5.5 W
Hastelloy D.....	0.12 ¹	1.0 ¹	1.0 ¹	Bal.	3.8-4.25	8.5-10.0	.....	.....	0.80-1.25	.....
Aluminum.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99.6 Al
Lead.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99.9 Pb
Silicon Iron.....	0.85 ¹	Bal.	.....	.....	.....	14.5	.....	.....	0.50-0.65	.....
Durimet 20.....	0.07 ¹	Bal.	19.0-21.0	28.0-30.0	4.0	1.0	3.0	.....	.....	.....

¹ Maximum

² Minimum.

LEGEND: † Low Corrosion Rates.
‡ Moderate Corrosion Rates.
‡ High Corrosion Rates.

TABLE 2—Corrosion Data

CORRODENT	Con- centration	Steel	Cast Iron	Ni-Re- sist	Copper	Al Bronze Sn Bronze	Si Bronze	12 Cr Steel (Type 410)	17 Cr (Type 430)	18 Cr 8 Ni (Type 304)	18 Cr 12 Ni 2 Mo (Type 316)	27 Cr (Type 446)	25 Cr 12 Ni (Type 309)	25 Cr 20 Ni (Type 310)	Monel	Nickel	Inconel	Hastel- loy A	Hastel- loy B
Acetic Acid.....	100	.....	.....	.....	.....	.....	.....	400‡	.....	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
Acetic Acid Vapor.....	100	.....	.....	.....	.....	.....	.....	.....	.....	500‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
Alcohol (Ethyl).....	100	450‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aluminum Potassium Sulfate.....	10	400‡	.....	.....	.....	.....	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aluminum Sulfate.....	25	.....	.....	.....	500‡	500‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ammonia Liquid.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	400‡ ¹⁰	.....	.....	.....	400‡	.....	400‡	.....	.....
Ammonium Chloride.....	100	.....	.....	.....	.....	.....	.....	850‡	850‡	850‡	.....	.....	.....	.....	700‡	700‡	700‡	700‡	700‡
Barium Chloride.....	100	.....	.....	.....	.....	.....	.....	.....	.....	1900‡ ¹	.....	.....	.....	.....	.....	.....	900‡	.....	.....
Benzoic Acid.....	100	.....	.....	.....	.....	.....	.....	.....	.....	400‡	.....	.....	.....	.....	500‡	400‡	1900‡	.....	.....
Boric Acid.....	10	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	25	500‡	.....	.....	500‡	500‡	500‡	.....	.....	.....	.....	.....	.....	.....	500‡	.....	.....	.....	.....
.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	30	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	50	.....	.....	.....	.....	.....	.....	.....	.....	400‡	.....	.....	.....	.....	400‡	.....	.....	.....	.....
.....	60	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	400‡	.....	.....	.....	.....
.....	75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	80	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Boron Phosphate.....	100	600‡	600‡	.....	600‡	600‡	600‡	600‡	600‡	600‡	600‡	.....	.....	.....	600‡	600‡	600‡	600‡	600‡
Boron Phosphate Vapors.....	100	600‡	600‡	.....	600‡	600‡	600‡	600‡	600‡	600‡	600‡	.....	.....	.....	600‡	600‡	600‡	600‡	600‡
Bromine (Dry).....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Carbon Dioxide.....	100	900‡	900‡	900‡	900‡	500‡	500‡	900‡	900‡	900‡	900‡	.....	.....	.....	900‡	900‡	900‡	900‡	900‡
Carbon Monoxide (Gas).....	100	900‡	900‡	900‡	900‡	500‡	500‡	900‡	900‡	900‡	900‡	.....	.....	.....	900‡	900‡	900‡	900‡	900‡
Chlorine (Gas).....	100	470‡	400‡	.....	500‡	500‡	.....	900‡	900‡	900‡	.....	.....	.....	.....	600‡	700‡	900‡	900‡	900‡
.....	100	485‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	700‡	850‡	1000‡	.....	.....
Copper Chloride.....	100	400‡	.....	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500‡	500‡	500‡	.....	.....
Copper Sulfate.....	10	.....	.....	.....	500‡	500‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	20	.....	.....	.....	500‡	500‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dimethyl Sulfide.....	90	.....	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	400‡	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fluorine.....	100	400‡	.....	.....	400‡	400‡	.....	.....	.....	.....	.....	.....	.....	.....	900‡	900‡	.....	.....	.....
.....	100	900‡	.....	.....	900‡	900‡	900‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Formaldehyde.....	50	600‡	600‡	600‡	600‡	600‡	600‡	.....	.....	600‡	.....	.....	.....	.....	600‡	600‡	600‡	.....	.....
Furfural.....	100	450‡	450‡	.....	400‡	400‡	400‡	.....	.....	400‡	.....	.....	.....	.....	400‡	.....	.....	.....	.....
.....	100	.....	.....	.....	550‡	550‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fatty Acids.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hydrofluoric Acid.....	100	600‡	600‡	600‡	900‡ ¹¹	900‡ ¹¹	900‡ ¹¹	400‡	500‡	400‡	600‡ ³	.....	.....	.....	600‡	500‡	600‡	600‡	600‡
.....	100	.....	.....	.....	.....	.....	.....	600‡ ¹¹	600‡ ¹¹	600‡ ¹¹	.....	.....	.....	.....	700‡ ¹¹	900‡ ¹¹	.....	.....	.....
Hydrogen.....	100	.....	400‡	400‡	700‡	700‡	900‡	1300‡	1550‡	1650‡	.....	.....	.....	.....	700‡	700‡	900‡	900‡	900‡
.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hydrogen Chloride.....	100	600‡ ³	500‡	400‡	450‡	450‡	400‡	900‡	900‡	800‡ ³	.....	.....	.....	.....	700‡	700‡	800‡	.....	.....
(Anhydrous).....	100	.....	.....	.....	600‡	600‡	500‡	.....	.....	.....	.....	.....	.....	.....	850‡ ³	900‡ ³	900‡	.....	.....
.....	100	900‡ ³	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hydrogen Chloride (Wet)	4	536‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	4	787‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	20	536‡	536‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hydrogen Chloride (Wet)	37	536‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(With Air).....	20	440‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	20	536‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hydrogen Sulfide.....	90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	500‡	500‡	.....	.....	.....	.....	600‡	900‡	900‡	.....	.....	.....	.....	500‡	500‡	800‡	500‡	500‡
.....	100	700‡	700‡	.....	.....	.....	.....	700‡	.....	.....	.....	.....	.....	.....	600‡	600‡	900‡	.....	.....
Lead (Molten).....	100	900‡	900‡	.....	650‡	650‡	650‡	600‡	600‡	600‡	600‡	.....	.....	.....	600‡	600‡	600‡	650‡	650‡
Methylamine.....	40	400‡ ¹	.....	.....	.....	.....	.....	.....	.....	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	80	400‡ ¹	.....	.....	.....	.....	.....	.....	.....	400‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mercury.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Maleic Anhydride Vapors.....	100	400‡	400‡	400‡	400‡	400‡	.....	.....	.....	400‡	.....	.....	.....	.....	600‡ ³	600‡ ³	600‡	700‡	700‡
Naphthenic Acid.....	100	500‡	500‡	600‡	.....	.....	.....	500‡	500‡	.....	.....	.....	.....	.....	400‡	400‡	400‡	400‡	400‡
.....	100	600‡	600‡	700‡	.....	.....	.....	600‡	600‡	.....	.....	.....	.....	.....	600‡	600‡	600‡	.....	.....
Nickel Nitrate.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nitriding Gases.....	100	700‡	.....	.....	.....	.....	.....	700‡	700‡	700‡	.....	.....	.....	.....	.....	900‡	.....	900‡	900‡
.....	100	850‡	.....	.....	.....	.....	.....	850‡	850‡	850‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oleic Acid.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500‡	450‡	600‡	.....	.....
Oxidizing Gases.....	100	1000‡	1000‡	1200‡	800‡	800‡	900‡	1300‡	1500‡	1600‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	1100‡	1200‡	1400‡	900‡	900‡	.....	1400‡	1600‡	1750‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phenol.....	90	500‡ ¹²	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	500‡ ¹²	.....	.....	.....	.....	.....	500‡	.....	600‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	100	600‡ ¹²	.....	.....	.....	.....	.....	600‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phosphoric Acid.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	10	.....	.....	.....	500‡ ⁶	500‡ ⁶	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	25	.....	.....	.....	500‡ ⁶	500‡ ⁶	500‡ ⁶	.....	.....	.....	.....	.....	.....	.....	500‡ ⁶	.....	.....	.....	.....
.....	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	50	.....	.....	.....	500‡ ⁶	500‡ ⁶	500‡ ⁶	.....	.....	.....	.....	.....	.....	.....	500‡ ⁶	.....	.....	.....	.....
.....	60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	65	500‡	500‡	550‡	500‡ ⁶	500‡ ^{6</}													

LEGEND: † Low Corrosion Rates.
§ Moderate Corrosion Rates.
‡ High Corrosion Rates.

TABLE 2—Corrosion Data Cont'd.

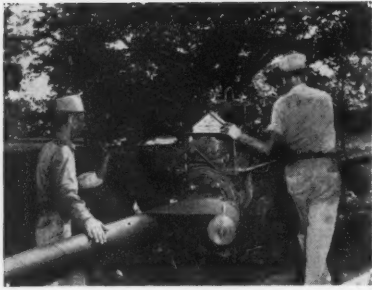
	Con- centra- tion	Steel	Cast Iron	Ni-Re- sist	Copper	Al Bronze Sn Bronze	Si Bronze	12 Cr Steel (Type 410)	17 Cr (Type 430)	18 Cr 8 Ni (Type 304)	18 Cr 12 Ni 2 Mo (Type 316)	27 Cr (Type 446)	25 Cr 12 Ni (Type 309)	25 Cr 20 Ni (Type 310)	Monel	Nickel	Inconel	Hastel- loy A	Haste- loy B
CORRODENT																			
	90	.....	600X	.....	.....	.....	.....	.....	.....	900X ³	.....	.....	.....	.....	900X ³	550? 900? ³	800X	.....	.....
	95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	100	700X ³	600X	600X	700X	700X	.....	700X	700X	600X ³	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sodium Nitrate.....	100	700X ³	.....	.....	.....	.....	.....	.....	.....	900X ³	.....	.....	.....	.....	900X ³	800X ³	.....	.....	.....
	100	900X ³	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sodium Sulfate.....	15	.....	.....	.....	500X	500X	500?	.....	.....	.....	.....	.....	.....	.....	500?	.....	.....	.....	.....
Stannous Chloride.....	100	500?	400?	500?	.....	.....	.....	400?	400?	500?	.....	.....	.....	.....	700?	700?	700?	700?	700?
Stearic Acid.....	100	400X	.....	.....	.....	.....	.....	.....	.....	500X	400?	.....	.....	.....	000?	500?	600?	600?	600?
Sulfur.....	100	500?	400?	400?	.....	.....	.....	700?	700?	700?	.....	.....	700?	.....	400? ⁶	400? ⁶	800? ⁶	.....	.....
	100	600X	500X	500X	.....	.....	.....	800X	800X	800X	.....	.....	.....	.....	500X?	500X?	900X ⁶	.....	.....
Sulfur Chloride.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	700?	400?	400?	400?
Sulfur Containing Oils.....	100	400?	400?	400?	.....	.....	500?	650X?	650?	650X?	.....	.....	.....	.....	400?	400?	400?	400?	400?
(15%S)	100	500X	500X	500X	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	550X	550X	550X	550X	550X
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sulfur Dioxide.....	90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	100	1100?	900?	.....	.....	.....	500?	1200?	1200?	1200?	900?	.....	.....	.....	600?	600?	1500?	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	700X	700X	.....	.....	.....
Sulfur Trioxide.....	90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	100	1100?	900?	.....	.....	.....	.....	1200?	1200?	1200?	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sulfuric Acid.....	5	.....	.....	.....	500X ⁶	500X ⁶	500X ⁶	500X	500X	500X	.....	.....	.....	.....	500X?	500X?	.....	.....	500X
	10	.....	.....	.....	400X ⁶	400X ⁶	400X ⁶	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	25	.....	.....	.....	400X ⁶	400X ⁶	400X ⁶	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	70	.....	.....	.....	.....	.....	.....	500X	500X	500X	.....	.....	.....	.....	500X?	500X?	500X?	.....	500X
	75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500X
	85	400X	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500X
	90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500X
	95	650X	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500?
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500?
Sulfurous Acid.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Silicotungstic Acid.....	85	.....	.....	.....	500X	500X	.....	.....	.....	.....	500X ¹⁰	.....	.....	.....	700?	900?	1100?	.....	.....
Steam.....	100	900?	400?	900?	.....	.....	.....	900?	900?	1200?	.....	.....	.....	.....	700?	900?	1100?	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	800X	.....	.....	.....	.....
Tall Oil.....	100	500X	500X	.....	500X	500X	.....	.....	.....	500X	.....	.....	.....	.....	500?	500?	500?	.....	700?
Vinyl Chloride.....	100	.....	.....	.....	.....	.....	.....	.....	.....	900?	.....	.....	.....	.....	.....	.....	.....	.....	.....
Zinc Chloride.....	100	500?	400?	500?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	700?	700?	700?	.....	700?
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Zinc Sulfate.....	25	.....	.....	.....	500?	500?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

LEGEND: † Low Corrosion Rates.
§ Moderate Corrosion Rates.
‡ High Corrosion Rates.

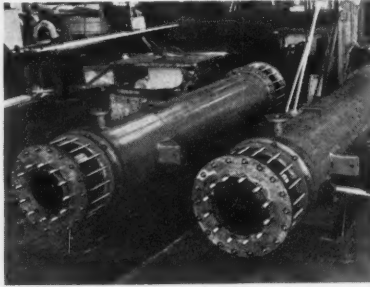
TABLE 2—Corrosion Data Cont'd.

CORRODENT	Con- centration	Hastel- loy C	Hastel- loy D	Alumi- num	Lead	Duri- met 20	Silicon Iron	Glass & Stone- ware	Tan- talu- m	Plati- num	Red Brass	Yellow Brass	Kar- bate	As- bestos	Cr 1/2 Mo	21 Cr 4Al	Silver	Chem- ical Re- sist- ing Brick (8)	Silicate Ce- ments (8)
	90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	400X ^{1,2}	.....	.....	.....	.....	.....	.....	.....
	95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	700X	700X ^{1,2}	.....	.....	.....	.....	.....	.....	.....
Sodium Nitrate.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Sodium Sulfate.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Stannous Chloride.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Stearic Acid.....	100	600?	600?	400?	.....	.....	600?	600?	500?	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Sulfur.....	100	800?	.....	700?	.....	700?	.....	400X	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
	100	.....	.....	700?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Sulfur Chloride.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Sulfur Containing Oils.....	100	.....	.....	400?	.....	.....	.....	.....	.....	.....	500X	650?	.....	.....	.....	.....	.....	1750?	1750?
(1.5% S)	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500?	.....	.....	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	600?	.....	.....	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	700X ^{1,6}	.....	.....	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	800?	.....	.....	.....	.....
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	800?	.....	.....	.....	.....
Sulfur Dioxide.....	90	900?	.....	.....	400?	.....	.....	.....	.....	.....	.....	.....	.....	.....	900?	.....	.....	.....	.....
	100	900?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750 ⁹
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sulfur Trioxide.....	90	900?	900?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	100	900?	900?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sulfuric Acid.....	5	.....	500X	.....	500X ⁷	.....	.....	.....	.....	.....	600X ⁶	500X ⁶	.....	.....	.....	.....	.....	1750?	1750?
	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
	25	.....	500X	500X	500X ⁷	.....	500X	500X	.....	500?	500X ⁶	500X ⁶	.....	.....	.....	.....	.....	1750?	1750?
	70	.....	.....	.....	.....	.....	.....	.....	500?	400?	.....	.....	400X	.....	.....	.....	.....	1750?	1750?
	75	.....	.....	.....	.....	.....	400?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
	80	.....	500X	.....	.....	.....	500?	500?	.....	500?	.....	.....	400X	.....	.....	.....	.....	1750?	1750?
	85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
	90	.....	500X	.....	400X ⁷	.....	500?	500?	.....	500?	.....	.....	400X	.....	.....	.....	.....	1750?	1750?
	95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
	100	.....	500?	.....	.....	.....	400?	500?	.....	500?	.....	.....	400X	.....	.....	.....	.....	1750?	1750?
Sulfurous Acid.....	100	.....	.....	.....	400?	400?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Silicotungstic Acid.....	85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Stram.....	100	.....	.....	500?	.....	.....	.....	.....	.....	.....	.....	.....	400?	900?	.....	.....	.....	1750?	1750?
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Tall Oil.....	100	.....	.....	600X	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Vinyl Chloride.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Zinc Chloride.....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?
Zinc Sulfate.....	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1750?	1750?

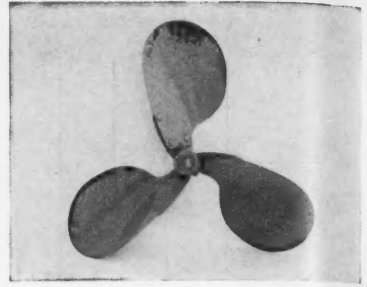
¹ Pts. Details in Report of NACE Technical Unit Committee T-6K (In Preparation).
² De-Zincifies. ³ Stress Cracks. ⁴ Intergranular Corrosion. ⁵ Stress Relieved. ⁶ Air Free. ⁷ Depends Upon Air. ⁸ Refer to Construction
⁹ Admiralty. ¹⁰ Fluoride Free. ¹¹ 5 Cr. ¹² pH>7. ¹³ Special Silicate Cements to 2200 F. ¹⁴ Type 317. ¹⁵ Air Free. ¹⁶ Sulfur Free.



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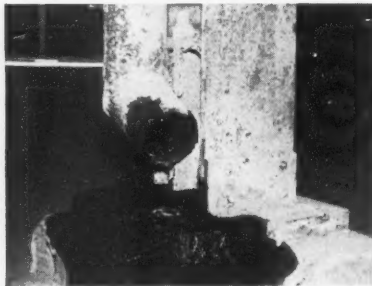
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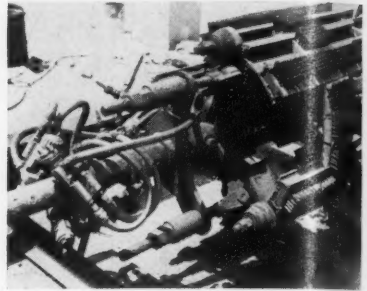
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Farm Equipment



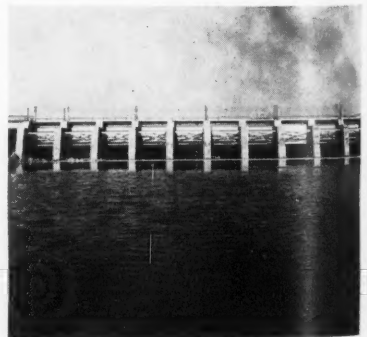
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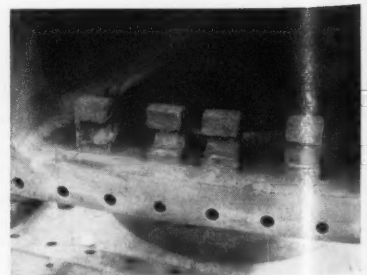
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NACE News

Northeast Region Meeting Will Open May 9



SPRING NORTHEAST REGIONAL CONFERENCE COMMITTEE is shown here at a planning meeting in New York City. Left to right: J. C. Howell, Public Service Electric and Gas Corp.; F. B. Koeffler, Barret Division, Allied Chemical & Dye Corp.; J. I. Montel, Hammond-Montel Co.; E. J. Doyle, American Telephone and Telegraph Co.; F. E. Kulman, Consolidated Edison Co. of New York; F. J. LeFebvre, Electro Rust-Proofing Corp.; C. R. Johnson, Port of New York Authority; S. W. Shepard, Chemical Construction Corp.; N. N. Ehinger, Aluminum Company of America; E. F. Miller, Hills-McCanna Company; I. Washburn, Devoe & Reynolds Co.

Extensive Technical Program Outlined For New York Meet

An extensive technical program has been arranged for the three-day spring meeting of Northeast Region. The May 9-11 sessions will be held at Hotel Statler, New York City. The regional meeting is sponsored jointly by the NACE regional organization and the Metropolitan New York Section.

The program has been announced as follows:

Tuesday, May 10

Control Galvanic Corrosion; Stop Costly Failures by E. C. Reichard, American Smelting and Refining Co.

Electrochemistry of Inhibitor Action by R. B. Mears, United States Steel Corp.

Inhibiting Corrosion of Steel, Aluminum and Magnesium Intermittently Exposed to Brines by George E. Best, Mutual Chemical Company of America.

Economics of Painting by J. Cogshall, Pennsylvania Salt Manufacturing Co.

Aluminum for Structural and Architectural Applications by Ellis D. Verink, Jr., Aluminum Company of America.

Stainless Steels for Structural and Architectural Applications by E. A. Tice, International Nickel Co., Inc.

Wednesday, May 11

Recent Navy Experience With Saran and Vinyl Coatings by W. W. Cranmer, Philadelphia Navy Yard.

Latest Developments in Marine Coatings by Raymond Devoluy, The Glidden Company.

Integration of Corrosion Control in Pier Substructures by C. R. Johnson, Port of New York Authority.

A New Test Method to Determine the Resistance of an Insulating Joint by E. T. Pearson, Public Service Electric and Gas Co.

The Use of Graphite as Duct Anodes by A. L. Ayres, New Jersey Bell Telephone Co.

Induced AC Used for Cathodic Protection of Coated Pipe Line by S. J. Bellassai, Transcontinental Gas Pipe Line Corp.

Potential Criteria for Cathodic Protection by Francis W. Ringer, consultant.

Other Events Programmed

Technical Committees of NACE have been invited to meet May 9, first day of the meeting. On Wednesday evening, a fellowship hour is planned. Two luncheons are scheduled also.

Attendance is not limited to NACE members. Registration details and other information may be obtained from F. J. LeFebvre, Electro Rust-Proofing Corp., P. O. Box 178, Newark, N. J.

Schedule of Topics Given for Washington U 5-Day Corrosion Short Course Sept. 12-16

Topics to be covered during a 5-day Short Course on Corrosion at University College and the School of Engineering, Washington University, St. Louis, have been revealed. The course, to be held September 12-16, will be given with the cooperation of the National Association of Corrosion Engineers.

In addition to technical events, the university also plans to make available to enrollees interesting social occasions. Space will be made available also for holding informal discussions and to provide for demonstrations of corrosion testing equipment in the evenings. These added events will be contingent on the degree of interest in them by enrollees. The tentative schedule is as follows:

Monday, Sept. 12

9 am-12 noon—Corrosion Theory, Reactions, Factors and Fundamental Mechanisms.
2-5 pm—Metallurgical and Mechanical Factors Affecting Corrosion.

Tuesday, Sept. 13

9 am-12 noon—Types of Corrosion—Diagnosis and Treatment of Corrosion Difficulties, Including Designing to Prevent Corrosion.
2-5 pm—Treatment of Environments—Chemical Methods, Selection and Behavior.

Wednesday, Sept. 14

9 am-12 noon—Selection of Materials of Construction for Particular Environments.
2-5 pm—Corrosion Testing Methods and Evaluation.

Thursday, Sept. 15

9 am-12 noon—Cathodic Protection—Theory and Measurement.
2-5 pm—Cathodic Protection—Practical Application and Economics.

Friday, Sept. 16

9 am-12 noon—Protective Coatings (Metallic and Organic)—Fundamentals and Selection.
2-5 pm—Protective Coatings—Surface Preparation, Application and Behavior.

Electrolysis Committee Is Discussed at Toronto

Approximately 22 members and guests attended the March 22 meeting of the Montreal Section at the Queen's Hotel in Montreal. C. Dunbar of the Bell Telephone Company of Canada, spoke on "The Purpose and Necessity of an Electrolysis Committee." Mr. Dunbar is a member of the Southern Ontario Electrolysis Committee. Preceding the speaker's address there was a short business meeting.

Ulmer Discusses Boiler Water at Baltimore

R. C. Ulmer discussed the subject of Newer Ideas in Boiler Water Treatment for use in the marine, industrial and utility fields during the February 15 meeting of the Baltimore Section. Corrosion problems encountered at supercritical conditions, use of hydrazine for control of oxygen in high pressure boilers, decomposition of water by radiation and problems involved in boilers using nuclear power were included in the talk.

Dr. Ulmer pointed out that pH of water and dissolved oxygen concentration were two of the most troublesome things in steam generating plants and discussed conventional control of these. He revealed water decomposition by radiation and special corrosion problems encountered in nuclear reaction require unusual care in selection of materials of construction for such boilers. Dr. Ulmer stressed that water treatment must be at very minimum in supercritical boilers because of accelerated behavior of power-house chemicals at these critical conditions.

Southwestern Ohio Section Nominates New Officers

At the March 29 meeting of Southwestern Ohio Section, the following were announced as nominees for officers of the section, 1955-56: Al Jenss, chairman; Clifford Jones, vice-chairman; R. Leonard Wood, treasurer and Lewis M. Lederer secretary. This slate of officers was elected unanimously.

Reports were given on various aspects of the national convention held in Chicago March 7-11 and it was an-

nounced that Frank L. Whitney, Jr., recently elected president of NACE, would speak at the April 26 meeting.

Irvin Levinson of Ampco Metals presented a talk on "Copper, Copper Alloys and their Resistance to Corrosive Elements."

V. B. Pike of the Bell Telephone Laboratories presented a paper covering the work done by his company on "Grounding" at the February 22 meeting. Twenty-eight members and guests were present.

Industrial Painters' Course Starts at Corpus Christi

Corpus Christi Section, National Association of Corrosion Engineers is sponsoring an Industrial Painters' Course March 28-May 16 at Corpus Christi. The meetings will be held at the Change House Meeting Room, located at the main entrance of the Delhi-Taylor Corp. There is no fee and those attending six of the eight sessions will receive a certificate.

The sessions and the topics to be covered are:

March 28—Surface Preparation Equipment. Mr. Oakes, Clemco Co.

April 4—Application Equipment. DeVilbiss Co.

April 11—Primers, Oleoresinous Coatings in General and Their Application. Mr. Crawford, Humble Paint Co.

April 25—Neoprene and Rubbers. Mr. Snyder, Houston.

May 2—Alkyd Resins, Cold Galvanizing processes, Phenolic Coatings—Baked, Catalyzed and Modified. John W. Nee, Briner Paint Mfg. Co.

May 9—Hot Application of Paint, Vinyls, Mastics—Also Asphaltic Mastics and Bitumen Mastics. Spee-Flo Co., Houston. Lester Brusse.

May 16—Safety, Inspection and Costs. Ed Kunkel, Celanese Corp.

A tabular topical index of the contents of the Corrosion Abstract Section of Corrosion is published annually in December.

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Repair on corroded water header pipe at Celanese Corporation of America



NATIONAL, REGIONAL MEETINGS and SHORT COURSES

1955
May 5-6—South East Region, Birmingham, Alabama

Oct. 18-21—South Central Region, Shamrock Hotel, Houston

Nov. 17-18—Western Region, Sir Francis Drake Hotel, San Francisco, California

1956
Mar. 12-16—NACE International Corrosion Conference and Corrosion Show, Statler Hotel, New York, New York
Oct. 2-5—South Central Region, Beaumont, Texas

1957
Mar. 11-15—NACE Annual Conference, Kiel Auditorium, St. Louis, Missouri

1958
Mar. 17-21—NACE Annual Conference, Civic Auditorium, San Francisco, California

1959
NACE Annual Conference, Sherman Hotel, Chicago, Illinois.

SHORT COURSES

1955
Sept. 12-16—Washington University, St. Louis.

November—University of California—NACE Western Region. Process Industries.

Dec.—University of Illinois, Urbana. Cathodic Protection.



NACE MEETINGS CALENDAR

May

11 Metropolitan New York. Regional meeting. Hotel Statler, 33 St. & Eighth Ave., New York City, 10 a. m.

12 Kanawha Valley. Topic to be announced. Huntington, West Virginia.

13 Philadelphia. Topic to be announced. Poor Richard Club, Philadelphia. Dinner: 6:30 p. m.; meeting, 8 p. m.

16 or 21. Lehigh Valley. Plant visitation.

17 Chicago Section. Annual Corrosion Round Table.

19 Greater Boston. Topic to be announced. Beaconfield Hotel, Brookline, Mass.

June
Niagara Frontier. Social Meeting—Ladies Night.

Nominations for 1955 NACE Awards

Nominations of persons to receive the Whitney or Speller Awards, accompanied by statements showing the basis of the nominations should be sent to Regional Chairmen before June 1. Nominations may be made by Sections or by individual members. A copy of the NACE Awards Procedure will be mailed to members in the next few days.

Silicones Are Discussed at Corpus Christi Meeting

Approximately 35 members and guests who attended the March 22 meeting of the Corpus Christi Section heard Ted B. Goldman of the Dow Corning Corporation speak. Mr. Goldman spoke on the use of silicones in industry, showing the many uses to which silicones are put in industrial plants. Mr. Goldman used slides to illustrate many of these uses.

During the business portion of the meeting, the following new officers of the section were installed: Paul H. Laudadio, chairman, Briner Paint Mfg. Co.; Kenneth R. Sims, vice-chairman, Gas Dept. of Public Utilities; Robert C. Dill, secretary-treasurer, Reynolds Metal Company.

Annual Houston Section Social Meeting Scheduled

The annual social meeting of Houston Section will be held May 10 at the Texaco Country Club and a special invitation has been issued to the ladies. At the following Section meeting, June 14th, members will hear D. R. Fincher speak on "Gasoline Plant Corrosion." Mr. Fincher is associated with Tide Water Associated Oil Co., Weimar, Tex.

Corrosion in the Home Is Topic at Houston Session

Corrosion engineers who work full time to keep down corrosion losses in industrial installations, learned at the March 22 Houston Section meeting how corrosion hits them in their own pocket-books in their homes. Principal subjects discussed were: water heaters and internal pipe corrosion, external pipe corrosion and automobile corrosion.

Speaking on water heaters and internal pipe corrosion, Robert L. Featherly, The Dow Chemical Co., Midland, Mich., commented on the various types of water heaters now in use, including galvanized, Monel, copper and steel with glass lining. He explained the use of magnesium anodes in cathodic protection for iron units. In commenting on piping he discussed black iron, galvanized and copper pipe and said the trend is now towards copper pipe.

Troubles With Home Piping

The troubles and economics involved in external corrosion of gas and water piping to homes was discussed by Gordon L. Doremus, Cathodic Protection Service, Houston. Mr. Doremus explained that since gas companies are responsible for maintenance up to the gas meter which is near the house, there is little external corrosion of gas pipes to worry the home owner. In water pipes, trouble is generally caused by bronze couplings or similar parts which cause galvanic attack on iron pipe.

Corrosion frequently is bad in oxygen deficient areas. Another cause of severe corrosive attack in the Houston area is low soil resistivity, according to Mr. Doremus. In comparing use of copper pipe with use of iron pipe protected with anodes, the cost is about the same provided the iron pipe is well insulated so that no loss to neighbor's lines occurs.

Neutral ground installations from electric utilities are a big source of trouble and must be isolated to prevent dissipation of anodes, Mr. Doremus said.

Protection for Automobiles

Donald W. Wing, Schlumberger Well Surveying Corp., Houston, divided his discussion of automobile corrosion into corrosion of frames, combustion systems and cooling systems. In frame protection, he emphasized the use of a good coating on a well prepared surface. If the coating is not applied at the factory, or before dirt accumulates on the surface, it is of little value, he said. Chrome plating which peels or chips speeds corrosion because chrome is cathodic to steel.

In combustion systems, many types of

mufflers are available, but none are perfect. Aluminized steel seems to be the best of materials available, he said.

Corrosion of cooling systems can be reduced by the use of inhibitors, usually contained in most antifreezes. Some of the better inhibitors are chromates, borax and nitrites. Alcohol and glycol are acceptable antifreezes, Mr. Wing said and added that cooling systems should be drained and cleaned once a year.

In the discussion period, numerous questions were asked about water heaters, dishwashers and other home appliances. Mr. Doremus went into greater detail about insulating subsurface piping and Mr. Wing answered numerous questions in regard to automobile undercoatings and cooling systems.

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- Top-ranking chemical organizations use Primer P-50 as the plant-wide "work horse" primer, under Prufcoat Protective Coatings and conventional paints, as well.

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- Easy to handle—you use it like any conventional primer.

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- Starts your protective coating application off on the right foot—not with ½ mil, not with 1 mil, but with 2 mils or more in the prime coat alone!

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- Bonds well to practically all old sound coatings and paints—you make a simple, practical transition from existing conventional paints to chemical resistant coatings without sandblasting!

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SPECIMENS OF CORRODED WELL EQUIPMENT shown here were used by H. L. Bihartz, Production Profits, Inc., to illustrate points on his April 11 talk before North Texas Section at Dallas. His topic was secondary recovery.

Dehn Talks at Dallas On Nondestructive Testing

North Texas Section met March 14 in the White Plaza Hotel, Dallas for its regular monthly meeting. Approximately 16 members and four guests were present to hear George L. C. Dehn, Magnaflux Company, Dallas speak on Non-Destructive Testing. Mr. Dehn described methods used by his company to test metals without altering or affecting the use of the part in any manner.

BACK ISSUES of CORROSION WANTED!

NACE will pay \$1.00 each for copies of the following back issues of Corrosion:

- 1947—January, March, June, July, August, November, December, September
- 1948—January, February, May, June, July, August, December
- 1949—January, February, March, June, July, August, September, October
- 1950—January, February, April, May, September
- 1951—January, February, March, October

Anyone interested in selling any of the above listed issues of Corrosion please send them to National Association of Corrosion Engineers, 1061 M & M Building, Houston 2, Texas.

Masonry Construction Is Pierce's Topic at Orange

The March 31 meeting of the Sabine-Neches Section held at the Little Mexico Restaurant, Orange, Texas, was attended by 25 members and guests. R. R. Pierce of the Pennsylvania Salt Manufacturing Company, Philadelphia, spoke on Chemically Resistant Masonry Construction. Mr. Pierce outlined history and development of chemically resistant masonry construction in the United States and Europe. The requirements, properties, advantages and disadvantages of three base materials, 22 membrane materials and three brick types were covered. Silicate, sulfur and resin type cements were also discussed and good design practices were illustrated with slides.

It was announced that the next meeting of the section would be held April 28.

Permian Basin Section

At the March 14 meeting of the Permian Basin Section at the Petroleum Club of Odessa, F. J. Radd of the Continental Oil Company spoke on "Petroleum Metallurgy."

During the business portion of the meeting, it was suggested that the Permian Basin Section, NACE, support the forthcoming water flood tour sponsored by the Permian Basin Water Flood Association of Monahans on May 23.

The meeting was attended by approximately 55 members and guests.

Portland Cement Is Panel Topic for Detroit Session

The April 14 meeting of Detroit Section was scheduled to be a panel discussion on corrosion resistance of Portland cement, Lumnite cement and additives to cements, all in reference to chemical plant environment. The panel consisted of William Lerch, Manager Applied Research Laboratories, Portland Cement Association; Dr. W. C. Hansen, Manager Research Laboratories, Universal Atlas Cement Company; W. G. Brown, Director of Research, Western Waterproofing Company of Detroit.

James Cogshall, Technical Representative of Corrosion Productions Department of Pennsylvania Salt Manufacturing Company is scheduled to speak on Economics of Plant Maintenance Painting at the May 26 meeting of the Section. The meeting has been planned to attract applicators and men in the plant maintenance field.

New Orleans-Baton Rouge Section Has New Officers

New officers of New Orleans-Baton Rouge Section 1955-56 who took office March 28 are as follows: J. R. Matherne, Southern Bell Telephone and Telegraph Company, New Orleans, chairman; Lee N. Spinks, Cathodic Protection Service, New Orleans, vice-chairman; Robert M. Robinson, Continental Oil Company, New Orleans, secretary-treasurer.

C. L. Barr was appointed trustee of the section.

Four Correspondents Are Added to Corrosion Staff

New correspondents have been appointed to the Corrosion staff by Dr. Ivy Parker, editor, as follows:

F. E. Kulman, Consolidated Edison Co. of New York for the power industry. I. S. Levinson, Process Industries, Ampco Metal, Inc., Milwaukee, Wis. for non-ferrous metals.

Edward J. Doyle, American Telephone and Telegraph Co., New York for telephone, telegraph and radio industries.

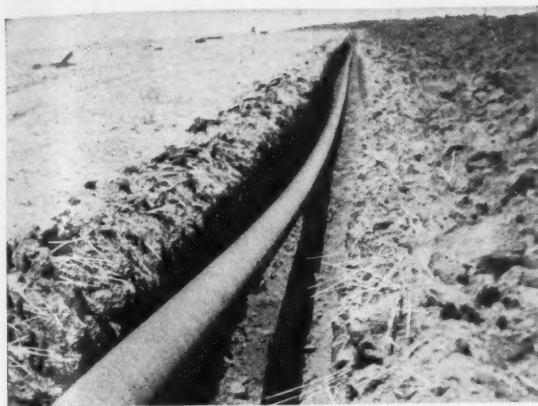
H. O. Teeple, The International Nickel Co., Inc., New York, for pulp, paper, mining and food industries.

The principal activity of these correspondents is to supply one article each a year for the Topic of the Month page.

More than 50,000 copies of reprints of technical material published in Corrosion during 1954 have been made.



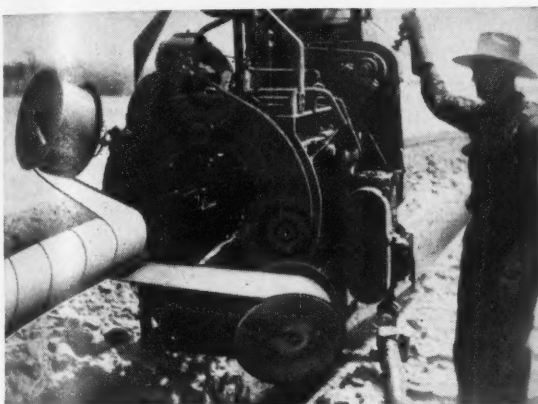
POLICY AND PLANNING COMMITTEE is shown during its March 7 meeting at Chicago. Seated at the table are E. P. Noppel, Ebasco Service, Inc., New York City, chairman (left) and A. B. Campbell, NACE Executive Secretary (right).



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Recent Applications of Carbon Anodes Reviewed At Los Angeles Session

J. P. Oliver, special sales representative of the National Carbon Co., Chicago spoke on Recent Applications of Carbon Anodes during the February 23 meeting of the Los Angeles Section held at the Rodger Young Auditorium in Los Angeles. Approximately 60 members and guests attended.

Mr. Oliver described application of cathodic protection in 3-inch lead sheathed ducts holding telephone service lines against corrosion caused by moist atmosphere within ducts and from accelerated corrosion caused by local hot spots, particularly at cable duct joints. He explained approximately 500 feet of tandem connected anodes 18 inches long and two inches wide, spaced at nine foot centers within the ducts were pulled through these and current supplied at one end of anode run.

Application of carbon anodes attached to underside of stern of a river boat on the Monongahela River near Pittsburgh was also described by Mr. Oliver. He revealed that combination of factors including presence of steel mill pickle liquor, chemicals, metallic particles and other debris contributed to river water pH of approximately 3.5 and aid in causing an \$8000 annual corrosion loss of steel plates on underside of boat.

Anode installation consisted of twelve 36-pound carbon anodes concentrated in pattern around propellers and twin court nozzles of boat where corrosion damage was usually greatest, Mr. Oliver said. Bottom of boat was coated with vinyl paint coating before start of test and current supply for cathodic protection system was taken from boat's 110-volt supply with test indicating desirability of having separate power supply for protection system.

Current for test was approximately 9 amperes per 2000 square feet of surface or a protective current of .0045 amperes, he explained. After six months' operation inspection of bottom surface showed paint film intact and other visual evidence of good corrosion protection with area of court nozzles in good condition showing damage only on leading edges which was probably caused by erosion by contact with river debris, he revealed.

Stress Corrosion Discussed By San Francisco Section

Bob Cunningham of Standard Oil Company at Richmond, California, spoke on stress corrosion to the 64 members and guests attending the March 23 meeting of San Francisco Bay Area Section. Mr. Cunningham's talk was followed by a film entitled "A Study in Stress Corrosion" which was furnished by Dr. M. G. Fontana of the Ohio State University.

Professor Cornet of University of California and R. S. Treseder of Shell Oil Company provided discussions based on information furnished them by Dr. Fontana.

At the January 10 meeting of the San Francisco Bay Area Section, the following officers were installed: H. H. Scott, Shell Oil Company, chairman; G. J. Puckett, The Dow Chemical Com-



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1956 Conference to Have International Flavor; Subcommittee Chairmen for Session Named

pany, vice-chairman, and W. P. Simmons, Alloy Steel Products Company, secretary-treasurer.

The meeting, being a joint one with the American Society of Metals was attended by 90 ASM members and 50 NACE members. G. A. Nelson, Metallurgist, of Shell Development Company, presented a paper on the subject of Metals for High Pressure Hydrogenation Plants. Mr. Nelson's knowledge of both case histories and theoretical details were evident in his talk. He also presented accurate application data which was most helpful to those attending.

J. A. Oslin, Jr.

J. A. Oslin, Jr., 41, chief maintenance engineer at Magnolia Petroleum Company's Refinery at Beaumont, Texas, died March 28 after a short illness. A native of Fort Worth, he was a graduate of the University of Texas. He was a corporate member of NACE representing Magnolia Petroleum Co.

He is survived by his widow and one daughter.

Portland Section

Pierre Van Rysselberghe, professor of chemistry, University of Oregon, spoke on "New Methods of Corrosion Investigation" at the March 9 meeting of the Portland, Oregon Section. The 35 members and guests present heard Dr. Van Rysselberghe describe the use of the polarograph in the study of corrosion phenomena. He also discussed the construction of potential pH diagrams and their use.

The meeting was held jointly with the American Electroplater's Society.

Uhlig Talks at San Diego

H. H. Uhlig of the Massachusetts Institute of Technology spoke to 113 members and guests of the San Diego Section March 11 on Modern Trends in Corrosion Control. Dr. Uhlig's 1½ hour presentation attracted representatives of the ASCE, ACS and members of other national technical organizations from all southern California. His discussion dealt with modern trends in combating various types of corrosion.

More than 50,000 copies of reprints of technical material published in Corrosion during 1954 have been made.

Efforts are being made to encourage visitors and participants from Mexico, South America, Canada, England, Japan and the European nations to attend the National Association of Corrosion Engineers' International Corrosion Conference and 1956 Corrosion Show scheduled in New York City, March 11-16. Exhibits and program are to be given an international character where possible by Technical Program Chairman W. Z. Friend, The International Nickel Co., Inc., New York City, and Exhibits Chairman Clark A. Baily, Johns-Manville Corp., New York City.

Connections are being established with the United States State Department and foreign embassies as well as the United Nations, whose headquarters in New York City has facilitated some activities of the local arrangements committee under the co-chairmanship of F. J. LeFebvre, Electro Rust-Proofing Co., Newark, and F. E. Kulman, Consolidated Edison Co., New York City.

Conference general chairman Kempton H. Roll, technical director of the Lead Industries Assn., New York City, stated: "Since NACE's Twelfth Annual Convention and Exposition has been scheduled for New York, it was decided that this would provide an excellent opportunity to enlarge the scope of the meeting to that of an international conference devoted to corrosion—a subject of universal concern. At the same time, an international atmosphere will be injected wherever possible into the 1956 Corrosion show, held concurrently with the conference."

Subcommittee chairmen for the conference have been appointed as follows:

Registration and Information—H. W. Dieck, Long Island Lighting Co.

Transportation—M. Bermann, Brooklyn Union Gas Co.

Hotel and Meeting Rooms—N. N. Ehinger, Aluminum Co. of America, New York City.

Conference Coordination—E. G. Brink, American Viscose Co., Marcus Hook, Pa.

Printing—H. O. Teeple, The International Nickel Co., Inc.

Entertainment—E. F. Miller, Hills McCanna Co., Jackson Heights, N. Y.

Publicity—J. C. Klinger and O. Klinger, Oildom Publishing Co., Bayonne, N. J.

Hospitality—J. D. Bird, The Dampney Co., Boston.

Ladies Activities—Mrs. B. J. Bailey, Consolidated Edison Co., New York City.



Technical Committee News

Seven Committees Meet in Houston October 18-19

Skinner Is Vice Chairman Of High Temperature Corrosion Unit T-5B

Dr. E. N. Skinner of the International Nickel Co., Inc., was elected vice chairman of Unit Committee T-5B on High Temperature Corrosion at the committee's meeting during the March Conference in Chicago.

T-5B has completed its initial project on compiling high temperature corrosion data. The committee's report on the project including the compilation of the data is published in the Technical Section of the May issue of Corrosion.



SKINNER

In discussing future projects for attention by the committee, four new task groups were agreed upon and the old Task Group T-5B-1 on High Temperature Corrosion Testing was discontinued.

New Task Groups

T-5B-2 on Sulfide Corrosion at High Temperatures and Pressures in the Petroleum Industry. Eight members of T-5B have been appointed to the task group and M. E. Holmberg, 4101 San Jacinto Street, Houston, Texas was appointed temporary chairman. An organizational meeting is planned for the week of May 8 at the Jefferson Hotel in St. Louis, Missouri. Anyone interested in participating in the task group activities should contact Mr. Holmberg.

T-5B-3 on Oil Ash Corrosion: Considerable study has been conducted by various companies and institutions on vanadium ash corrosion. Task Group T-5B-3 is being formed to correlate the results of the several independent studies. Anyone interested in participating in these activities should contact John Halbig, Armco Research Labs., Middletown, Ohio.

T-5B-4 on High Temperature Halogenation: This task group will undertake a study of corrosion by chlorine at temperatures above 1000 F. Anyone interested in participating in the activities of this group should contact John Halbig, Armco Research Labs., Middletown, Ohio.

T-5B-5 on Corrosion by Molten Salts and Metals: This group will undertake a study to determine the existing data on resistance of various high temperature metals to fused salt corrosion such as experienced in salt bath furnaces. Anyone interested in participating in these activities should contact John Halbig, Armco Steel Labs., Middletown, Ohio.

Committees Invited To These Sessions

South Central Region: October 18-21, 1955, Shamrock Hotel, Houston, Texas. October 18 and 19 being reserved for Technical Committee meetings. To reserve meeting space notify: T. J. Hull, NACE, 1061 M & M Bldg., Houston.

Northeast Region Meeting: October 31-Nov. 3, 1955, Niagara Falls, New York. October 31 being reserved for Technical Committee meetings. To reserve meeting space notify: T. J. Hull, 1061 M & M Bldg., Houston. (Meetings must be scheduled by August 1, 1955.)

Western Region Meeting: November 17 and 18, 1955, Sir Francis Drake Hotel, San Francisco, California. To reserve meeting space notify: T. J. Hull, 1061 M & M Bldg., Houston.

41 Are Present for Coatings Research Session

Forty-one members and guests attended the organizational meeting of Unit Committee T-6R on Protective Coatings Research held during the 1955 NACE Conference. The committee was organized to study projects and activities of other technical committees whose work runs parallel to the work of T-6 unit committees. The committee will also make recommendations for possible T-6 projects which are not now covered by any T-6 unit committee.

T-6R is cooperating with the FPVPC Corrosion Committee and its project on Minimum Paint Film Thickness for Economical Protection of Hot Rolled Steel Against Corrosion. R. H. Steiner, Atlas Mineral Products Co., Mertztown, Pennsylvania, is chairman of T-6R and is acting as NACE's representative on the FPVPC project.

Stray Current Electrolysis Report Discussed by 96

A preliminary report on Stray Current Electrolysis was discussed by the 96 members and guests present at the T-4B-6, Stray Current Electrolysis meeting in Chicago. The report is a summary of replies to a questionnaire circulated by the committee. The summary will be completed and submitted to members of the committee for approval.

After approval by T-4B-6 it will be submitted to T-4B for approval and subsequent publication.

Parts of a report entitled "Summary of General Practices as Pertaining to Bonding and Grounding of Cable Sheaths for Corrosion Mitigation" were also discussed. This report will also be submitted to T-4B-6 members and subsequently to T-4B for approval to publish as a committee report.

South Central Region Allocates Two Days To Technical Groups

Seven technical committees have already asked that meeting space be reserved during the 1955 South Central Region Meeting.

The meeting will be held at the Shamrock Hotel, in Houston, Texas, October 18-21, 1955. The two days October 18 and 19 are being reserved exclusively for technical committee meetings. Adequate meeting space and facilities are being provided for as many committees as may desire to hold a meeting.

A committee meeting schedule for the South Central Region meeting will be published in this section of Corrosion in the July issue.

An excellent technical program is being planned for the last two days of the meeting. Tentatively symposia are being prepared on Corrosion Inhibitors, Public Utilities, Cooling Towers, Chemical Process Industries, Oil and Gas Production, Protective Coatings, Cathodic Protection and General Pipe Line Corrosion.

In addition there will be small group discussions on Pipe Line Corrosion problems.

Shrempp Is New Head of T-1A on Corrosion of Oil and Gas Equipment

F. W. Schrempp of the California Research Corp., La Habra, Calif., is the newly elected chairman of NACE Technical Unit Committee T-1A on Corrosion in Oil and Gas Well Equipment in the Los Angeles Area. Howard Lorenz, Standard Oil Co., Taft, Cal., is the new vice-chairman, and John Pryor, Shell Oil Co., Long Beach, Cal., the new secretary. Frank E. Davie, Shell Oil Co., Los Angeles, outgoing chairman of T-1A, reported to Group Committee T-1 at the meeting in Chicago that T-1A held eleven meetings during 1954. The following subjects were topics discussed at the meetings: Free pump corrosion, marine corrosion, hydraulic unit power oil corrosion, chemical inhibitors, chemical handling, alloy vs. carbon rods, nondestructive equipment testing, cathodic protection and casing corrosion.

T-1A presented a paper entitled "Corrosion Treatment of Pumping Wells in California" at the spring meeting of the Pacific Coast District, Division of Production, American Petroleum Institute in 1954. The paper was based in part on the committee report published in Corrosion, 1954.

T-1A currently is working on an up-to-date survey of corrosion control in pumping wells and expects to present the report at the next annual NACE Conference.

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Scope of Prefabricated Plastic Film Committee Is Defined at Chicago Meeting of T-2K

T-5D on Plastic Materials of Construction Plans Symposium for 1956

Unit Committee T-5D on Plastic Materials of Construction in the Process Industries has voted to present a technical symposium at the 1956 NACE Conference in New York. The symposium has been approved tentatively by the chairman of the 1956 technical program committee and R. B. Seymour, Atlas Mineral Products, Mertzown, Pa., has been appointed chairman.

Ninety members attended the T-5D meeting in Chicago. B. J. Philibert, Olin-Mathieson Chemical Corp., Baltimore, Md., took over as chairman of T-5D at the meeting succeeding R. B. Seymour. Mr. Seymour was instrumental in organizing the committee and served as the first chairman. S. W. McIlrath, Diamond Alkali Co., Euclid, Ohio, is the new vice-chairman.

During the meeting R. B. Seymour gave a preliminary report on the second T-5D questionnaire. Over 500 copies of the questionnaire were mailed out to interested companies. He reported that statistically the interest in plastics as materials of construction is wide-spread. The complete report on the questionnaire will be available soon and will probably be published in the technical committee activities of Corrosion.

The committee has agreed to circulate a third questionnaire. It will be prepared for distribution to manufacturers, suppliers and fabricators of plastics.

Fundamentals Task Group

Task Group T-1D-1 on Fundamentals of Corrosion held its organizational meeting during the Chicago Conference. J. D. Sudbury, Continental Oil Co., Ponca City, Okla., is the chairman of the group.

Formation of the task group was authorized by T-1 at the meeting in Dallas in October 1954. The scope of the task group includes an attempt to bring up to date present state of knowledge on the fundamental mechanism of 1) sour corrosion, 2) sweet corrosion, 3) corrosion inhibitors. The committee expects ultimately to be in a position to recommend needed research either by individual companies or as sponsored research.

HF Corrosion Group

A new task group to study "HF Corrosion" has been formed by Unit Committee T-5A on Corrosion in the Chemical Process Industries. T. L. Hoffman of the Phillips Petroleum Co., Atomic Energy Division, Idaho Falls, Idaho, has been appointed chairman of the committee and is organizing its activities. The committee will consider problems of corrosion related to fluorine, hydrofluoride and hydrofluoric acid.

Task Group T-5A-3 on Acetic Acid will prepare a progress report during 1955. The task group plans to have the report ready for presentation at the next annual NACE conference.

Forty members and guests attended the organizational meeting of new Unit Committee T-2K in Chicago during the recent NACE conference.

The committee decided to make the official name of the committee "Prefabricated Plastic Film for Pipe Line Coating." The following objectives were agreed upon:

1. To prepare a history of the use of prefabricated plastic films such as pressure sensitive tapes with experience and results obtained.

2. To study bonding agents or adhesives including the proper application to the pipe where an adhesive or catalyzed bonding agent is applied to pipe and a plastic film is applied separately. To study the water solubility, osmosis created by cathodic protection, oil and hydrocarbon solubility of bonding agents, chemical resistance, etc.

3. To study prefabricated plastic films available now and as they are discovered in the laboratory, paying particular attention to plasticizers to eliminate the possibility of a poor plasticizer causing a breakdown of an otherwise good film. Also to study the moisture transmission rate and chemical resistance, etc., of plastic films.

4. To study the proper application of both pressure sensitive tapes and prefabricated films as applied to pipe lines, specifically as pipe line coatings with recommendations for proper use.

5. To study the characteristics of plastic pressure sensitive films used for pipe protection and to establish standard methods for the measurements of the characteristics.

R. B. Bender, Plastic Engineering and Sales Co., Fort Worth, Texas, was instrumental in organizing the committee and acted as temporary chairman at the organizational meeting. He resigned as chairman at the Chicago meeting. The permanent chairman of T-2K will be appointed in the near future.

Coatings Recommendations For Marine Use Sought

An outline to be followed by Unit Committee T-6E on Protective Coatings for Resistance to Marine Corrosion in organizing its activities was agreed upon at the committee's meeting in Chicago. The committee will develop a recommended practice for the application of coatings, the minimum requirements for equipment to apply coatings, a guide for coating inspectors and a suggested maintenance practice to realize the most out of a coating.

D. F. Dial, Jr., Pure Oil Co., Houston, Texas, chairman of the new T-6E Committee on Corrosion of Oil and Gas Producing Equipment in Offshore Installations discussed progress made and future plans of T-6E.

J. L. Robertson, Phillips Petroleum Co., Bartlesville, Oklahoma, Chairman of T-6E, was re-elected.

New Department Set Up

A Department of Metallurgical Engineering has been established in the New York University College of Engineering.

POSITIONS WANTED and AVAILABLE

- Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
- Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.
- Advertisements to other specifications will be charged for at standard rates.

Positions Wanted

Metallurgical Engineer—BS degree, age 32, family. Ten years diversified experience in material specification, metals finishing, heat treating, corrosion. Now employed. Seeking permanent position with progressive northern California organization. Excellent references. CORROSION, Box 55-10.

Chemical Engineer—Professional license for really responsible position. Six years staff consultant to maintenance, production, purchasing personnel on all phases materials of construction in multiphase chemical company. Two years pilot plant supervision organic process development. CORROSION, Box 55-11.

Graduate Electrical Engineer—Licensed in two states, member NSPE and NACE, over 20 years active engineering experience partly in corrosion engineering work for the Navy, desires to become affiliated with an engineering or large industrial concern as a consultant or direct corrosion department operations. South or Southeastern USA preferred. CORROSION, Box 55-15.

Project Engineer—BSME-PE—18 years experience in project, plant and design engineering in organics, inorganics, pharmaceuticals and plastics. Any location considered. CORROSION, Box 55-12.

Positions Available

Corrosion Engineers. Positions available for graduate electrical engineers or equal. Previous field and design experience in corrosion mitigation systems required. Extensive travel involved. Salary open. The Hinchman Corp., Engineers, Francis Palms Bldg., Detroit 1, Mich.

Sales Representatives for DEL Protective Coatings. Protected territories available to qualified individuals or companies. No objection to carrying non-competitive lines. Write David E. Long Corp., 220 East 42nd St., New York 17, N. Y.

Corrosion Engineer—Graduate engineer with field and design experience in cathodic protection systems. Extensive travel. Salary open. Harco Corporation, P. O. Box 7026, Cleveland 28, Ohio.

Sales Engineer—Chemical background. Protective coating sales helpful. Age 23-44. Outstanding lifetime career selling complete line established corrosion resisting organic coatings. Take immediate charge Texas, Louisiana. Salary, expenses, commission, benefits. Replies Confidential. CORROSION, Box 55-13.

Metallurgist

Graduate mechanical or metallurgical engineer with minimum 7 years' experience in analyzing and resolving metallurgical problems relating to ferrous and non-ferrous metals. To render technical service to operating departments and serve as a staff consultant in the Company's overseas operation located in Saudi Arabia.

Must be thoroughly familiar with metallography laboratory techniques and be capable of establishing laboratory procedures and the training of technicians. He should have complete knowledge of alloys suitable for refinery processing and be capable of investigating failures possibly due to improper materials or operating procedures and recom-

mending remedial action. Salary commensurate with experience and training.

Plant and Equipment Inspectors

Two graduate engineers to develop inspection methods, supervise and conduct inspections and advise operations in connection with codes, equipment limitations, etc. in a major oil installation located in Saudi Arabia.

Senior Inspector—Minimum ten years' experience in design or inspection of petroleum processing plants and equipment, of which five years must have been in inspection work entailing general knowledge of all facilities.

Inspector—Minimum five years experience maintaining and inspecting pressure vessels and oil handling equipment. Thorough knowledge of API and ASME codes for fired and unfired pressure vessels and piping is required. Salary commensurate with experience and training.

Interested candidates should write directly to the Recruiting Supervisor, Box 92, Arabian American Oil Company, 505 Park Avenue, New York 22, N. Y.

MANAGERIAL PERSONNEL NEEDED For Research Center in the Petroleum Industry

Ente Nazionale Idrocarburi (E.N.I.) has under its supervision a number of Italian Companies active in the field of petroleum and petrochemicals. ENI's major activity is centered in the following items:

Gas and oil field exploration and exploitation (current production: 150 billion cu. ft. of natural gas per year);

Operator of a 2500-mi. pipe-line system (capacity over 700 million cu. ft. per day);

Owner and operator of a tanker fleet of around 120,000 dwt;

Owner and operator of an extensive network for distribution of petroleum products and LP-gas throughout Italy (64 Bulk plants, 4000 stations, etc.);

Control over or shareholding in refineries having a processing capacity of about 6 million tons of crude oil per year;

Owner of factories (1500 employees) for construction of machinery;

Shareholding of chemical plants (700 employees) for production of synthetic dyes, detergents, etc.;

Under construction, a petrochemical plant (production capacity—30,000 tons per year of synthetic rubber and 350,000 tons per year of ammonium nitrate).

E. N. I. is organizing a big research center for investigation and development of petroleum processing and manufacture of petrochemicals. Some departments are expected to begin operation next summer.

Italian or foreign technical experts, with a wide educational background, specific training, organizational and managerial ability, are required to fill positions as heads of the main departments of the laboratories.

Specifically the following are sought:

- 1) *Chemist or physicist with specific knowledge and experience in thermodynamic and chemico-physical problems;*
- 2) *Chemist specializing in the preparation of organic compounds, particularly those derived from hydrocarbons;*
- 3) *Inorganic chemist soundly and completely acquainted with modern methods of experimentation, research and testing;*
- 4) *Engineer or industrial chemist specially trained in the methods for improving petroleum products applications;*
- 5) *Engineer or Physicist, with physico-technical and technological training, specialized in the problems of thermo-technics, measurements and controls;*
- 6) *Engineer or industrial chemist with extensive research experience in the field of crude oils processing;*
- 7) *Engineer or industrial chemist particularly experienced in extending laboratory procedures to pilot plants;*
- 8) *Engineer with good theoretical knowledge and laboratory experience in engine tests on fuels and lubricating oils;*
- 9) *Engineer or industrial chemist specially trained both in theory and practice in the fields of corrosion and protective means for materials.*

Note: University degree mandatory.

Applications should state age and other usual personal data, educational background and qualifications, practical experience, etc., and should include a photograph.

Please address personally to the: Presidente dell'Ente Nazionale Idrocarburi, Via Lombardia, 43—Roma—Italy, with the special note RISERVATA PERSONALE (i.e., to be opened by addressee only).

Absolute discretion in every respect is assured. Salary offered will be in accordance with position, training and qualities required.

13 Companies Report on Inhibitor Screening Test

Thirteen companies have reported results of using the Unit Committee T-1K standardized laboratory procedure for screening inhibitors for use in oil and gas wells published as a report of the committee in the March issue of Corrosion. This information was given to the 85 members and guests who attended the T-1K meeting in Chicago.

From the company reports it appears the biggest point of difference in running the test is in the matter of weight losses on the blank coupons and the absence or appearance of pits. The committee has decided to take the following steps:

1. Another set of corrosion inhibitors will be furnished to all those desiring them;

2. Coupons from the same steel and finished in the same manner will be furnished by one of the companies represented on T-1K;

3. A task group of T-1K will attempt to evaluate the pitting on the next group of coupons to see if any sort of standard pitting technology or evaluation can be used and another task group will attempt further work correlating the results of two laboratories on the problem of surface preparation as it affects the weight losses.

The committee reports that although there is still considerable disagreement in individual tests there is relatively good agreement in the results. It was also reported that insofar as statistics are concerned blank corrosion rate correlation has never been obtained on any

kind of test and the disagreement in individual weight losses reported in T-1K tests do not disagree any more between laboratories than within a single laboratory.

Although the committee has not yet answered the question as to what a good inhibitor should show on the test it appears that all inhibitors that have good records in the field have given about 85 to 95 percent protection when tested on the T-1K standard test at 10-25 ppm.

Aims of Tanker Corrosion Committee Are Discussed

Nine members of Unit Committee T-3H on Tanker Corrosion reported on their experience with tanker corrosion at the T-3H meeting in Chicago. W. S. Quimby, The Texas Company, New York, N. Y., chairman of T-3H, told the 80 members and guests of the aims and objectives of the committee and reviewed the need for cooperation in this serious problem of tanker corrosion.

Following the presentations by the nine members an active open discussion was held. Many questions were asked and answers or comments given. The general opinion of those attending the meeting was that a spirit of cooperation is clearly evident.

Several suggestions for setting up task groups to study specific problems were discussed. It is planned to appoint each of the 40 members of the committee to some specific task group.

Members may get the distinctive NACE membership pin for \$10.

Report Being Prepared on Concentration Cells

A report on concentration cells is being prepared by Task Group T-4B-1 on Lead and Other Metallic Sheaths for presentation to Unit T-4B and subsequent publication as an interim report.

Approximately 150 members and guests attended the T-4B-1 meeting held in Chicago during the recent NACE Conference. Reports were heard from four project groups on concentration cells, technical information on galvanic action, information on alternating current corrosion and development of technical information on corrosion by microbiological action.

A new project group was organized during the meeting to prepare a descriptive list of corrosion classifications causing sheath failures together with information on classification of corrosion products which may be used in reporting sheath failures to the task group. A. L. Ayres of the New Jersey Bell Telephone Co., Newark, New Jersey, has been appointed chairman of the new project group.

Because there is unusual interest in possible corrosion caused by alternating current, T-4B-1 voted to reorganize and enlarge the existing project group on this subject. W. S. Woodward of the New York Telephone Company, Bronx, New York, will act as chairman of the reorganized group.

More than 5000 copies of Corrosion published during 1954 were mailed from Central Office NACE. These were in addition to the regular monthly mailings of the magazine.

Corrosion engineers specify low-cost easy to fabricate BART Lectro-Clad steel pipe and sheet

In every industry faced with corrosion and contamination problems, Bart LECTRO-CLAD steel pipe, plate, sheet and fittings offer an economical, yet highly satisfactory and long-lasting solution. The ductile, adherent and pore-free electroplated nickel surface will withstand any fabricating process that the low carbon steel itself will withstand.

For low cost protection in all types of equipment for chemical, petroleum, pulp and paper and other process industries, specify Bart LECTRO-CLAD products.

Complete information and technical data on all sizes of steel pipe, sheet and fittings, LECTRO-CLAD with up to .015" of pure nickel, available on request.

Sheet of LECTRO-CLAD sheet steel being rolled, to fabricate industrial process equipment. The material can be welded, flame cut, die formed or sheared without difficulty, and will withstand high temperatures without separating.



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C-3



General News

Fundamentals Stressed at Gordon Conference

Gulbransen, Harwood Will Head Corrosion Sessions July 18-22

Fundamental Studies in Oxidation and Corrosion is the theme of the 1955 Gordon Research Conference on Corrosion to be held July 18-22. E. A. Gulbransen and J. J. Harwood, are respectively chairman and vice-chairman of the meeting.

The schedule of lectures is as follows: July 18—Theory and Nature of Surfaces. A. Gwathmey, chairman.

Application of Electron Instrumental Methods to the Study of Metal Surfaces by R. D. Heidenreich.

Structural Defects Produced by Cold Work and Their Possible Influence on Chemical Reactions by J. S. Koehler. The Nature of a Metal Surface as Suggested by Theories of Crystal Growth by N. Cabrera.

The Nature of a Metal Surface on an Atomic Scale, open discussion.

July 19—Substructure in Oxidation and Corrosion. J. J. Harwood, chairman.

Recent Concepts and Observations of the Structure of Grain Boundaries and Sub-boundaries by E. Machlin.

Chemistry of Grains and Grain Boundaries by R. Bakish.

Sub-Grain Boundary Corrosion Phenomena by M. Metzger.

Recent Investigations in the Field of Nucleation During the Oxidation of Pure Metals by J. Benard.

Influence of Substructure Upon Electrochemical Exchange, Electrodeposition and Oxidation of Metals by M. Simnad.

Oxide Substructure Formed on Single Metal Crystals by W. Harris.

July 20—Nature and Composition of Oxide Films. T. Rhodin, chairman.

Recent English Research on Films and Surface Layers on Metals by F. Wormwell.

Oxygen Adsorption on Stainless Steel by T. Rhodin.

Kinetics of Oxide Film Formation on Aluminum-Magnesium Alloys by W. Smeltzer.

Electrical Properties of Oxides. T. Rhodin, organizer. T. Gray, chairman.

Electron Transfer in Bulk Oxides of the Transition Metals by F. Morin.

Electrical Properties of Oxide Films on Metals by D. Vermilyea.

July 21—Studies on Oxidation of Metals. W. J. Moore, chairman.

Recent Developments in the Theory of Oxidation by N. Cabrera.

Diffusion Mechanisms in the Oxidation of Copper and Zinc by W. Moore.

Structural Aspects in the Selective Oxidation of Some Binary Alloys by J. Benard.

Studies on the Oxidation and Sulfidation of Iron by E. Birchenall.

Sub-Zero Hardening Is Feature of New Stainless Steel AM-350 Alloy

Hardening by subjection to -80 to -100 F temperatures increases the corrosion resistance of Allegheny Metal 350 stainless steels. The alloy has resistance comparable to Type 316 stainless and superior to that of Type 304 in boiling glacial acetic acid and 1 percent sulfuric acid at 100 F. Maximum resistance to attack by boiling 65 percent nitric acid is obtained in the sub-zero cooled condition without tempering. Nitric acid rates are greater than those of Type 304 but less than those of other hardenable stainless steels such as Type 410.

Resistance of AM-350 to pitting type attack in 20 percent sodium chloride salt spray test is excellent.

The alloy may be hardened also by a double aging process involving precipitation hardening heat treatment at 1300-1400 F for one or two hours and 800-900 F for one or two hours. Chromium carbides precipitate in the cooling interval between heats, altering the austenite so it transforms to martensite. Corrosion resistance in the double aged condition is not as good generally as in the sub-zero condition.

Extensive use for the metal in the aircraft industry is visualized because strength longitudinally and transverse is approximately equal because the high strengths of the AM 350 are obtained by heat treatment rather than by cold working. Because the alloy can be fabricated in the ductile condition and then hardened by cooling there is little change in dimension.

(These facts are condensed from "AM-350 . . . a new type of stainless steel," published in Vol. 17, No. 1, Steel Horizons, a publication of Allegheny Ludlum Steel Corp.)

Experimental Observations on the Cubic Law of Oxidation by J. Waber. July 22—Corrosion of Zirconium and Other Metals. D. Thomas, chairman. Electrical Properties of Oxide Films on Zirconium by R. Misch.

Inhibition of Corrosion by the Pertechinate Ion by G. Cartledge.

Subject to be announced. G. Adams, Jr.

Requests for attendance (limit 100) or additional information should be addressed to W. George Parks, Director, Dept. of Chemistry, University of Rhode Island, Kingston. From June 10 to September 2 mail should be addressed to Colby Junior College, New London, New Hampshire.

Manuscripts on corrosion subjects are accepted without invitation for review prior to publication in Corrosion.

LaQue Reviews U. S. Corrosion Activities In London March 31

A comprehensive review of corrosion activities in the United States was given by F. L. LaQue, vice president of The International Nickel Company, Inc., and manager of its Development and Research Division in New York, at a meeting of the Society of Chemical Industry in London March 31. Mr. LaQue was presenting the Society's Corrosion Spring Lecture for 1955.

He traced the history of several technical groups in the United States that deal with corrosion to a major extent. Particular reference was made to the Inter-Society Corrosion Committee sponsored by the National Association of Corrosion Engineers, this latter organization itself, the American Society for Testing Materials, the Electrochemical Society, the National Bureau of Standards and other governmental groups concerned with corrosion.

Mr. LaQue also reported on the results of a recent survey of education in corrosion in American engineering schools. This showed, he said, that there was some instruction in corrosion in 37 schools and that 550 students were taking these courses. In addition to these specific courses, corrosion is dealt with in at least one course in 103 schools. There is activity in corrosion research in 34 institutions, with 91 students being engaged in these activities.

After the lecture a colored sound motion picture covering activities at International Nickel's "Kure Beach" Corrosion Testing Station near Wilmington, North Carolina, was shown.

Testing Laboratories' Directory Is Revised

National Bureau of Standards Miscellaneous Publications M187 entitled Directory of Commercial and College Laboratories has been withdrawn and revision entitled Directory of Commercial and College Testing Laboratories has been issued by the American Society for Testing Materials. ASTM has undertaken responsibility for compilation and publication of directory in the future.

Information regarding location of testing laboratories together with types of commodities and nature of investigations laboratories are prepared to undertake are included in directory which is designed to assist large number of purchasers not equipped to make own acceptance tests and who therefore have hesitated to buy on specifications.

Extensive Corrosion Work Revealed by Armour

Blueprint for Progress is title of the 1954 Annual Report of the Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago 16. The following are brief descriptions of some of the projects which the Foundation had developed or was in the process of developing or studying during the period covered by the report.

It tested and developed construction materials that may be useful in chemical production of a corrosive metal.

Was concerned with development of ceramic materials resistant to thermal stress and which will absorb large quantities of heat.

Investigated factors contributing to air pollution in the Chicago area and made technical study of air pollution control legislation and associated problems.

Is attempting to develop a physical method of estimating ozone concentration in polluted atmospheres.

Atmospheric Pollution Data

That relatively insignificant amounts of unreacted and partially oxidized hydrocarbons are released into the atmosphere was established by field survey, in connection with laboratory program, of industrial and domestic burning devices operating on fuel oil, natural gas and liquefied petroleum gas.

Concluded an instrument development and construction program designed to eliminate or minimize objections to conventional method for determining finely divided solid and liquid airborne particles.

Studied smoke simulating colored

smokes from signalling grenades to establish relationship between particle size, shape and concentration of dye and color of smoke cloud.

Ammonia Synthesis

Technological survey indicated that appreciable tonnage of exceptionally pure iron ore might be used in manufacturing catalysts such as ammonia synthesis catalysts.

Carrier properties were studied with respect to physical and catalytic nature.

Conducted field studies to determine effectiveness of number of products as flocculating agents for suspended impurities in water.

Alkaline Pulp Digesters

Studied problem of corrosion in alkaline paper pulp digesters and made over 41,000 digester wall thickness measurements. Program resulted in series of positive conclusions regarding roles of materials of construction and several process variables as causes of corrosion.

Developed analytical procedures for evaluating some coal chemicals found in high temperature coke oven light oil and investigated chromatography and special distillation techniques as physical methods for isolating certain constituents in high purity.

Discovered that factors such as lubrication, structural composition, assembly, packaging and mechanism design contribute to deterioration of fine instruments during storage.

Furfuryl Resins Evaluated

Is investigating commercial applicability of Erik R. Nielsen's patented method for production of furfuryl alcohol resins with initial investigation leading to expectation that these can be extruded to form plastic pipe.

Attempting to develop polymerized vinyl chloride under controlled conditions to yield product for highly specific application.

Conducting project to determine effect of various storage variables on corrosion of truck and passenger car gears.

Is determining degree of protection from corrosion which various lubricants provide for truck and car gears during periods of storage.

Is investigating factors involved in lubrication and running characteristics of steel-to-steel bearing surfaces on unit gear transmissions with fretting corrosion of bearing surfaces being one of the factors studied.

Study of influence of several important parameters on coating properties to evaluate brittle coating more precisely under dynamic loading.

Properties of Brittle Coatings

Developed studies relating to properties of brittle coatings and determined influence of impact loading on coating strain sensitivity for several conditions of coating thickness, curing temperature and testing temperature.

Is making statistical study to determine influence of manufacturer's coating number, testing temperature, testing relative humidity, curing temperature and coating thickness on strain sensitivity of brittle coatings.

Study of stress distribution of compressor wheel dovetail at joint between blade and turbine wheel using photoelastic techniques and brittle coatings.

Alloys' Stability Probed

Completed study of constitution of magnesium-titanium-aluminum and magnesium-lithium-zinc alloy systems to provide insight into nature of their embrittlement and instability.

Conducted program to develop zirconium-base alloys which will be strong at elevated temperatures and have special nuclear- and corrosion-resistance properties. Certain titanium-base alloys were tested under similar conditions.

An exploratory investigation of failures of connectors, splices and taps particularly in situations involving junctions between aluminum and copper to establish performance standards for aluminum conductor sets. Troubles were apparently caused chiefly by corrosion and certain mechanical problems in making connections to the conductors, the report stated.

Determination of longitudinal and transverse Charpy V-notch impact properties of pipe line steels used in gas transmission lines.

In addition to evaluating number of metals for use under corrosive conditions, a protection technique was developed which shows promise for reducing corrosion of paper-making machines.

Stress Corrosion of Aircraft Alloys

Continued fundamental study of stress corrosion of aircraft alloys with emphasis on electrochemical effects produced by coupling various aluminum specimens in corrosion medium.

Is investigating chemical inoculants in gray iron.

Continued work on ingot quality as function of imposed vibrational energy with program designed to study occurrence and control of porosity and segregation, as well as grain refinement in vibrated castings.

Is conducting project directed toward recovery of manganese from open hearth slag to meet critical need for domestic source of this alloy addition.

New Titanium-Base Alloy

Development of titanium-base alloys of high strength and toughness resulted in at least one alloy, Ti-6% Al-4% V, which is 60 percent as heavy as steel, can be heat treated to tensile strengths of 170,000 to 190,000 psi with good impact strength at room and sub-zero temperatures, the report reveals.

Work was carried out on improved reduction process for ductile titanium metal.

Investigation of metallurgical characteristics of the 36 percent aluminum, titanium-base alloy was conducted.

Study was continued of nitriding as process for surface hardening titanium.

Is evaluating high-strength, weldable titanium-base alloys.

Properties of Alloy System

Program to obtain knowledge of influence of constitution and structure on the properties of an alloy system is being conducted.

Is conducting program to establish principles of heat treatment of titanium-base alloys and ranges of physical and mechanical properties which may be obtained thereby.

Initiated program to examine contribution to elastic modulus of dispersed intermediate alloy phases which have

(Continued on Page 78)

COKE BREEZE

Backfill for Galvanic Anodes

Ideally suited for use with galvanic anodes. Has a high carbon content and comes in 1/8-inch by O size. In bulk or sacks.

**GRAPHITE ANODES
MAGNESIUM ANODES
CEC RECTIFIERS
ELECTROLYSIS SWITCHES**

Wholesale Coke Supply

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MT. OLIVE, ALABAMA**

India Plans 15-inch Line Along Grand Trunk Road

Reduction of Smoke Seen as Benefit of Proposed Installation

Smoke nuisance caused by raw coal use in cities along the Grand Trunk Road from Dhanbad to Calcutta, India and consequent health deterioration of population is justification for banning raw fuel use for domestic purposes when gas can be supplied at cheap and competitive cost, according to an article entitled A Gas Grid for the Damodar Valley which appears in the September-October issue of *Science & Engineering*, the Organ of India Society of Engineers. Article points out that cleaner atmosphere would also save expenditures on maintenance of buildings and industrial plants.

It explains Damodar Valley is richly endowed for industrial development with most necessary raw materials such as coal, iron ore, bauxite, mica, refractory clays and electric power and water but lacks fuel-on-tap gas. Cheap and abundant supply and constant composition high-calorie gas is essential for industries where accurate control of temperature is necessary and fuel cost forms major part of manufacturing cost, the article states.

Coke Oven Gas Available

Confining its argument to available coke-oven gas, article says 50 percent is usually surplus with remaining normally used to heat ovens. It suggests use of producer gas or clean blast gas which cannot be easily marketed or disposed of to heat ovens, thus releasing almost entire quantity of coke-oven gas (10,000 cubic feet per ton of coal carbonized) for other uses.

As means of obtaining full utilization of coke-oven gas, article recommends trunk line be laid to Calcutta from Asansol (140 miles) or from Sindri (200 miles) because industries and gas centers are located along the Asansol to Calcutta route.

Considering sources of the gas, article estimates more than 20-30 million cubic feet daily of surplus coke-oven gas (equivalent to 200-250 thousand tons of coal per annum) could be made available.

Economics Is Surveyed

It reveals coal and gas in America compete with each other as long as distance of transmission does not exceed 200 miles, with cost decreasing on rise in heat values of gas and increasing as distance increases. Also, railway freights for coal decrease after certain distance. As comparison, Indian coal contains much high inherent ash and is of lower heating value, thus cost of transport favors gas for distance of 150-200 miles, article says.

15-Inch Pipe Line Needed

Article says cost of transmission would become disproportionately high if amount of gas distributed was less than 10 million cubic feet daily and benefits accruing would be small if amount exceeds 30 million cubic foot mark. Therefore, it says, 20-30 million cubic feet daily is most suitable figure in calculating needs of Damodar Valley for next 5-10 years. Transmission of 30 million cubic feet daily will require 300

lb. per square inch pressure and will justify a pipe line of 15-inch diameter.

It stresses that apart from fulfillment of ideals of complete utilization of coal resources and regional development of whole area from Asansol to Calcutta, gas grid would make a more substantial reduction in capital costs of investment and in final cost of gas supplied to consumers than by such planned methods as installation of new coke-ovens in Calcutta.

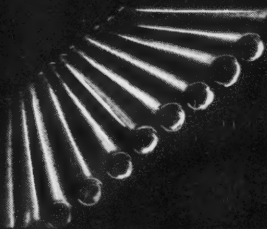
Considering the future, article states that planning should include integration of grid with at least two industries, viz. a low temperature carbonization industry and a synthetic oil industry so that fuel gas by-product of coal utilization processes could be obtained.

Organization Is Projected

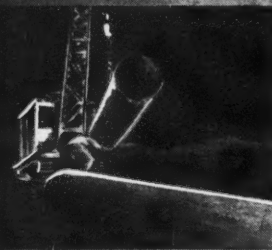
Recommended organization is that installation of main trunk line and components be undertaken by a state or public corporation which could enter into necessary agreements with suppliers of gas and be responsible for storage, compression and transmission up to point of distributor supply. Distribution to consumers could be left to private companies or corporations or could be state-owned.

Text of article is based on a report by Dr. A. Labiri, Fuel Research Institute, Dhanbad, to the Government of India and Government of West Bengal and was reproduced in abridged and edited form with due acknowledgment to *FRI News*, Vol. 2, No. 3.

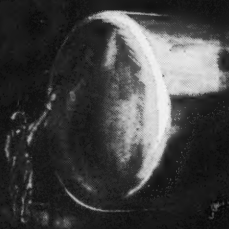
for HOT or COLD APPLICATION its Reilly coal tar coatings



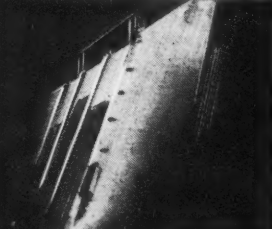
Pipe dip compound for cast iron pipes



230 (AWWA) Enamel for water lines



CA-5 for tanks and metal designed to serve underground and underwater



CA-50 for metal exposed to corrosive atmospheres, acid, salt, and alkaline, and against corrosion caused by condensation moisture

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Electrochemical Society Hears About Portable Orsat Gas Analyzer

A portable Orsat gas analyzer for determining hydrogen and chlorine concentration in chlorine gas from electrolytic cells as well as chlorine concentration by subsequent absorption is to be described during the Spring Meeting of The Electrochemical Society scheduled at the Sheraton-Gibson Hotel in Cincinnati, May 1-5. Analyzer was developed by Pennsylvania Salt Manufacturing Co.

Main feature of an amalgam cell developed by Vittorio de Nora of Italy which utilizes amalgam flowing vertically along supporting element and has diaphragms to separate cathode compartment from anode compartment will also be explained.

Technical sessions to be held during the 4-day meeting include 184 papers covering such subjects as electric insulation, electronics including luminescence, oxide cathodes, phosphor application and semiconductors, electrothermics and metallurgy, industrial electrolytics and theoretical electrochemistry.

Copies of program booklet are to be available about April 1 and may be obtained by writing Henry B. Linford, secretary of The Electrochemical Society, Inc., 216 W. 102nd St., New York 25.

Koppers and Firestone Cooperate on Brazilian Styrene Monomer Plant

Koppers Co., Inc. and The Firestone Tire & Rubber Co. have jointly announced joining with certain Brazilian interests to form the Companhia Brasileira de Estireno (Brazilian Styrene Co.) which is scheduled to construct and operate a plant at Cubato, Brazil, capable of producing 10 million pounds of styrene monomer annually.

Plant is to use ethylene from adjacent government-owned refinery and imported benzene to make styrene of which major portion will go to Brazilian manufacturers of polystyrene while lesser part will be made into styrene latices and high styrene polymers such as used in making shoe soles, the announcement read.

Koppers' Engineering & Construction Division is to design plant and erection will be by Brazilian contractors under general supervision of Koppers. Plant operation will be under management contract with Kopper's Chemical Division furnishing certain key personnel and other employees being Brazilian, according to the announcement.

It revealed that Koppers and Firestone will have slightly more than 50 percent, or controlling interest in the company.

Taylor Receives Award

Lauriston S. Taylor, National Bureau of Standards, has been presented the Gold Medal of the Radiological Society of North America for leadership in the field of radiation protection on a national and international scale.

Engineers, Architects Meet at Ohio University

AWWA Convention to Be Held at Chicago June 12-17

The 75th Annual Convention of the American Water Works Association is scheduled at the Conrad Hilton hotel in Chicago, June 12-17.

Design of Cement Lined Steel Pipe by E. S. Cole, Electrical Inspection of Coatings on Steel Pipe by Mark Davidson and New Development in Tests of Coatings and Wrappings by G. E. Burnett are included among subjects to be covered during the Distribution Division's Wednesday morning meeting. The Solution Effects of Water upon Cement/Concrete Linings of Water Mains by M. E. Flentje and R. J. Sweitzer is to be presented during the Division's Thursday morning meeting.

AWS Spring Meeting Set At Kansas City June 7-10

The American Welding Society's Spring Meeting and Welding Show is scheduled to be held in Kansas City, Mo., June 7-10. A symposium on welding qualifications and 36 papers in 11 sessions are included in the technical meeting. The symposium will consider basic principles involved in tests and procedures to qualify welders and best ways in which industry can apply qualification requirements. Papers will cover reports on new iron powder electrodes, use of carbon dioxide for weld shielding, fusion welding of titanium, self-fluxing brazing alloys which make use of small additions of lithium and high quality flame brazing set-up for fabricating electronic components.

LP Centrifugal Pump Standard Is Proposed

A proposal for standardization of low pressure centrifugal pumps has been submitted to the American Standards Association by the Chemical Industry Advisory Board. ASA said it had placed the proposal with more than 30 national organizations representing designers, manufacturers and users of the equipment and had issued invitations to interested groups asking attendance at a national conference scheduled April 7 in New York to decide whether a standards project should be initiated.

A comparison of commercially-available pumps shows many dimensions differ only slightly and for no obvious functional reasons and certain features lend to standardization without impairing manufacturer's competitive design, according to the report of a subcommittee of CIAB.

The national meeting is open to all who are concerned with use and manufacture of centrifugal pumps, ASA announced.

Fire Association Meeting

The 59th Annual Meeting of the National Fire Protection Association is scheduled to be held at the Hotel Netherland Plaza in Cincinnati, May 16-20.

The Second Annual Conference for Engineers and Architects was scheduled at Ohio State University, Columbus on May 6.

Technical papers include:

Ceramics in Aviation by Lloyd R. Richardson, Wright Air Development Center, Wright Patterson Air Force Base. Trends in Plant Design by Eugene Richman, professor, Ohio State University. Passivity of Stainless Steels—Current Research in the Corrosion Laboratory by William McKinnell. An Investigation of Cast Corrosion Resistant Alloys by Norbert Greene. High Temperature Effects of Boron in Steel by Robert M. Goldhoff.

Titles of current research projects in the College of Engineering at the University include:

Ceramic Engineering

Coatings for Protection of Ferritic Alloys at High Temperatures. Factors Contributing to the Protection of Metals by Inorganic Nonmetallic Coatings. Mechanisms of Adherence of Vitreous Enamel Ground Coats to Steel. Titanium Carbide Base Cermet. Oxide-metal Cermet Development. Cermet Coatings. Production of Super-duty Refractories.

Chemical Engineering

Properties of Fuming Nitric Acid. Polarization Characteristics of Aluminum and Stainless Steel in Fuming Nitric Acid and Their Application to Corrosion, Anodic Passivation and Cathodic Protection. Fluorocarbon Process Development. Deposition of Aerosol Particles on Screens. Biological Treatment of Phenolic Wastes.

Civil Engineering

Evaluation of Effects of Industrial Wastes on Sewage Disposal.

Instrument Conference Set for Los Angeles

"Instrumentation Paces Automation" is the theme of the 10th Annual Instrument Conference and Exhibit of the Instrument Society of America which is scheduled to be held at the Shrine Exposition Hall and Auditorium in Los Angeles, September 12-16.

Armour Report—

(Continued From Page 76)

high elastic modulus and of solid solution alloying additions to titanium.

Disproved theory that joint strengths required formation of intermetallic compounds at filler metal-base-metal interfaces. Diffusion bonding and self-fluxing brazing alloys are subjects of two patent applications based on this program.

Effect of Alloying Elements

Studied effects of alloying elements on weldability of titanium sheet.

Established fabrication practices essential to brazing of titanium heat exchangers.

Developed method and instrumentation for continuous evaluation of erosive properties of coal fly ash in turbine ducts.

Continued studies of fundamental nature and properties of solution ceramic coatings.

List of 1954 American New Standards Published

New American Standards Approved in 1954 is title of 12-page pamphlet issued by the American Standards Association, Inc., 70 E. 45th St., New York 17.

New standards include:

- A103.1-1954 (ASTM C 279-54) Specifications for Chemical-Resistant Masonry Units.
- C8.23-1954 (ASTM D 755-52T) Specifications for Performance Synthetic Rubber Compound for Insulated Wire and Cable.
- C8.29-1954 (ASTM D 574-46T) Specifications for Ozone-Resistant Type Insulation for Insulated Wire and Cable.
- C8.30-1954 (ASTM D 734-50T) Specifications for Polyvinyl Insulating Compound for Insulated Wire and Cable.
- C8.31-1954 (ASTM D 753-49) Specifications for GR-M Polychloroprene Sheath Compound for Electrical Insulated Cords and Cables Where Extreme Abrasion Resistance is Not Required.
- C8.32-1954 (ASTM D 752-49T) Specifications for GR-M Polychloroprene Sheath Compound for Electrical Insulated Cords and Cables.
- C8.33-1954 (ASTM D 1047-49T) Specifications for Thermoplastic Vinyl Polymer Sheath Compound for Electrical Insulated Cords and Cables.
- C8.34-1954 Specifications for Weather-Resistant Wire and Cable, Neoprene Type.

European Collaboration On Corrosion Is Topic

A discussion of European collaboration in the field of corrosion and the protection of materials was scheduled May 19 during the Congress of the European Federation of Chemical Engineering at Frankfurt-am-Main, Germany, 14-22 May.

FPVPC Convention Set

The 33rd Annual Meeting of the Federation of Paint and Varnish Production Clubs, and the 20th Paint Industries Show will be held October 3-5, 1955, at Hotel Statler, New York City.

Plastic Piping Is Topic

Plastic pipe will be discussed at a panel during the meeting May 10-13 in Houston of the Heating, Piping and Air Conditioning Contractors National Association. The meeting will be held at the Shamrock Hotel.

Design Show Postponed

The Design Engineering Show originally scheduled to be held in Philadelphia in May has been postponed until late Spring 1956 when it will be held concurrently with the Design Engineering Conference.

Authors of technical material published in Corrosion are indexed annually in December.

A tabular topical index of the contents of the Corrosion Abstract Section of Corrosion is published annually in December.

Flight Test Instrumentation Symposium Is Scheduled

The First National Flight Test Instrumentation Symposium sponsored by the Instrument Society of America is scheduled at Wichita, Kansas, May 3-5. ISA announced addition of a Computer Clinic to its 10th Annual Instrument-Automation Conference and Exhibit to be held at the Shrine Exposition Hall and Shrine Auditorium in Los Angeles, September 12-16.

Automation Exposition

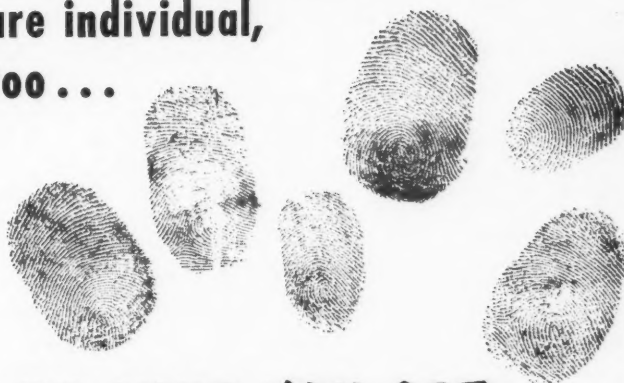
The Second International Automation Exposition is scheduled to be held at the Chicago Navy Pier, November 14-17, 1955.

FPVPC Appoints 10 to Corrosion Committee

Ten appointments to the Corrosion Committee of the Federation of Paint and Varnish Production Clubs have been announced. They are: J. W. Tomecko, Canadian Industries, Ltd., Montreal, chairman; W. Bosch, North Dakota Agricultural College, coordinator; H. L. Crawford, Houston; T. A. Dembski, New England; M. R. Feely, Toronto; C. M. Jackson, Louisville; C. G. Moore and G. G. Schurr, Chicago; J. Skala, Northwestern and G. H. Scott, Philadelphia.

Manuscripts on corrosion subjects are accepted without invitation for review prior to publication in Corrosion.

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BOOK REVIEWS

1954 Supplement to Book of ASTM Standards (Including Tentatives). 6 x 9 inches, 141 pages, paper. 1954. American Society for Testing Materials, 1916 Race St., Philadelphia, 3. Price not indicated.

This is the supplement to Part 4 on paint, naval stores, wood, cellulose, wax polishes, sandwich and building constructions and fire tests.

Recommended Practices for Metallizing. Part IC—Application of Metallized Coatings to Protect Against Heat Corrosion. 6 x 9 inches, 9 pages, paper. 1955. American Welding Society, 33 W. 39th St., New York 18. Per copy 50c.

Heat corrosion is the subject of this third in series titled "Recommended Practices for Metallizing." It provides an authoritative source of information dealing with application of metallizing to reduce heat corrosion for temperatures up to and over 1800 F. Equipment requirements and methods of surface preparation are listed in detail. Metallizing procedure including wire and sealer compositions and inspection tests are given as well as typical coatings for specific applications.

Cumulative Index To the First Fifteen Semiannual Reports To Congress. 6 x 9 inches, 118 pages, paper. 1954. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Per copy 35c.

A cumulative name and subject index guide to U. S. Atomic Energy Commission's first 15 semiannual reports to Congress which cover AEC's major unclassified activities from January 1947 through December 1953. Index supersedes earlier cumulative index to first nine and subsequent indexes to tenth through fifteenth semiannual reports.

Process Industries Applications of Alcoa Aluminum. 80 pages, 8½ x 11 inches, paper. 1955. Aluminum Company of America, Pittsburgh, Pa., Free.

A self-indexing, illustrated pamphlet describing the uses, assets and limitations of aluminum and its alloys in the process industries. It is divided into three parts: 1. Process Industries Applications. Typical uses are illustrated. Advantages are given and a table of the principal features and uses of the principal wrought and cast Alcoa alloys together with an index of the forms in which they are available is included. Some of the anti-corrosive advantages are listed. Part 2, called "A Service Dictionary," briefly describes the perform-

ance of aluminum exposed to various materials arranged alphabetically. This section includes flow charts of basic process layouts with indications where aluminum may be used. Text is keyed to the flow charts. Part 3, Design of Process Equipment, is devoted to mechanical considerations, process piping, corrosion considerations, clad products, cleaning methods, inhibitors, coatings, cathodic protection of and by aluminum and numerous technical reference tables. Illustrations of good and bad design are given.

National Plumbing Code. Minimum Requirements for Plumbing. 186 pages, 5½ x 7½ inches, paper. 1955. American Society of Mechanical Engineers, 29 West 39th St., New York, 18, N. Y. Per copy, \$3.50.

This is the uniform code developed after 20 years to modernize existing practices and coordinate the work of plumbing equipment manufacturers, architects, contractors, municipal law makers, building officials and others. The new code embodies a report by the National Plumbing Code Coordinating Committee which began work in 1949. The Standards Council of the American Standards Association said there was general agreement at a New York meeting of ASA

(Continued on Page 81)

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BOOK REVIEWS

(Continued From Page 80)

in November 1954 in favor of the code.

A careful search of the code fails to reveal attention to corrosion hazards except a provision for wrapping pipe to prevent external corrosion when it passes through or under cinder or concrete or other corrosive material. Ferrous pipe used underground shall be coal-tar enamel coated and threaded joints coated and wrapped after installation, the code states in another place. Galvanic corrosion apparently is not considered.

1955 Finishing Handbook and Directory. 5½ x 8¾ inches, 484 pages, cloth. 1955. Sawell Publications Ltd. 4 Ludgate Circus, London, E.C. 4. Per copy 37 shillings & sixpence (including 12 monthly issues of Product Finishing).

Fifth edition. Book extends information on finishing materials to 294 pages to include sections on chief types of paint, selection of paint schemes, paint application methods, finishes for aluminum alloys. Other subjects include anodizing applied plastic coatings, electroplating, flock coating, preparatory treatments and vitreous enamelling. Glossary of finishing terms and list of conversion factors and solvent flash points are provided.

Directory of equipment, plant and materials used in finishing field, out-working firms and trade and brand names is revised and extended to 192 pages. For easier reference section on finishing equipment is divided into general classifications corresponding with sections in handbook such as preparatory treatments, paint applications of equipment and plant and supplies for electrolytic processes. Included with each out-working firm's entry is information as to other finishing processes carried out and classification of these into geographical areas based on main British industrial centers.

Steam, Its Generation and Use. 8¾ x 11½ inches, 624 pages, cloth. 1955. The Babcock & Wilcox Co. 161 E. 42nd St. New York 17. Per copy \$10.

Thirty-seventh edition. Intended primarily for mechanical engineers and mechanical engineering students in the applied thermo field, book was prepared and edited by engineers and specialists of B&W. Each chapter is prefaced with a brief history of subject content providing the reader with the opportunity to develop an idea of advancement, problems, success of operation, and desired aims of subject treated. Replete with graphs, charts, tables, illustrations and formulae the book contains excellent material on variety of subjects such as principles of combustion, fluid dynamics, utilization of waste heat, steam temperature adjustment and control, selection of steam producing equipment, research and development, nuclear power and the Cyclone furnace. It contains comprehensive appendix to subject matter as well as index.

A tabular topic and alphabetical subject index to the material published in Corrosion's Technical Section is published annually in the December issue.

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NEW PRODUCTS — Materials — Service — Literature

A Cork Mastic spray coating for metal equipment said to combine corrosion protection with moderate degree of insulation is produced by Tar Products Division of Koppers Co., Inc., Pittsburgh 19. Called Bitumastic "K", product is recommended for use on oil and asphalt storage tanks, any metal tank whose contents are kept at temperatures up to 150 F, chemical plants or equipment, corrugated steel sidings and heating and ventilating ducts. Manufacturer claims coating requires no primer and one application produces protective covering up to one-half inch in thickness. Koppers Co., has announced plans to spend over \$20 million during 1955 for new plants and equipment and in enlarging and improving present production facilities. Completion of plant at Port Arthur, Texas to make polyethylene and one at Salem, Va., for the company's Wood Preserving Division are included in the plans.

Bacterial Development for sluggish septic tanks and cesspools called Formula FX-11 is announced by The FX-Lab Co., 4 Hill St., Newark 2. Manufacturer claims product's accelerated bacterial action clears pipes, baffles and cesspool sidewalls and gradually liquifies undigested particles that clog drainfield soil pores. FX-11 is safe to handle, non-corrosive to pipes and not harmful to septic tank or cesspool or necessary bacteria within, the company says. One quart is used for each 500 gallons capacity and is applied by pouring into toilet bowl and flushing.

A Polyethylene based self-bonding tape for protecting conduit joints against corrosive fumes is produced by Bishop Manufacturing Corp., Cedar Grove, N. J. Known as Bi-Seal Type 2, tape is said to be unaffected by acids, alkalis, fumes, gases, steam or other causes of corrosion, conforms to irregular shapes and may be applied to any type coupling or connector.

A Rigid Polyvinylchloride designated Haveg 1810 is described in the six-page Technical Bulletin No. 3 published by Haveg Corp., a subsidiary of Continental-Diamond Fibre Co., Newark, Del.

Stainless Tube and piping of intermediate alloy said to have greater resistance to stress corrosion cracking than 18-8 austenitic grades and to general corrosion than 12 and 18 percent chrome irons are manufactured by Alloy Tube Division of The Carpenter Steel Co., Union, N. J. Alloy known as Carpenter 7Mo is ideal for tubing and pipe applications subjected to chlorides, halogen ions, certain caustic solutions and acid conditions associated with food processing and for equipment for chemical processing, pulp manufacturing, petroleum refining and heat exchangers handling brackish water, the company says.

National Graphite Combustion Chambers and Karbate Impervious Graphite Burner Nozzles for production of hydrogen chloride are described in a seven-page catalog section available from National Carbon Co., a division of Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17. Section contains description of combustion chambers and burner nozzles with features on ability to burn wet gases, corrosion and thermal shock resistance, design characteristics and initial cost. Accessories recommended for burning various gases, installation and operating procedure are discussed. Information is supplemented by dimensioned drawings of chambers and nozzles. Designated Catalog Section S-7530, copies are available from the company.

Midwestern Engine and Equipment Co., Inc., Tulsa, henceforth will sell anti-corrosion products and pipe line supplies under the name Midwestern Pipe Line Products Co.

Treatment of Sewage Plant Effluent for Water Reuse In Process and Boiler Feed is subject of Technical Reprint T-129 available from Graver Water Conditioning Co. a division of Graver Tank & Manufacturing Co., Inc., 216 W. 14th St., New York 11. Reprint provides information on current developments and design factors in use of sewage effluent and discusses typical plant layouts, cost factors, applications and equipment. A bibliography is included.

Zinc Rich Coating said to resist humidity, weathering and submerged conditions is manufactured by The Sealube Co., Wakefield, Mass. Product can be brushed or sprayed on wire brushed

ferrous metal and lays down 93 to 95 percent pure metallic zinc to eliminate further corrosion, the company says. Manufacturer recommends coating for use on air conditioning central stations, interior and exterior of hot and cold water tanks, louvers, duct work, harbor installations and general maintenance. The Livingstone Coating Corp., 709 W. Third St., Charlotte, N. C. has been appointed southeastern distributor for Sealube products.

AB Hoganasarbeten of Stockholm, Sweden, contractors for acid and alkali proof constructions and sound conditioning installations will handle Norway, Sweden and Finland sales and application of products manufactured by Insul-Mastic Corp., 1141 Oliver Bldg., Pittsburgh 22.

Plicoflex No. 330, a laminated polyvinylchloride and rubber tape said to have high physical and dielectric strengths, exceptional stability and aging qualities, resistance to acids, alkalis and soil stress and low moisture absorption is produced by Plicoflex, Inc., 1566 E. Slauson Ave., Los Angeles 11. Manufacturer recommends product for use with butyl rubber coal tar base, butyl rubber coal tar resin asphalt or special Neoprene compound base resistant to action of crude oil and petroleum solvents. Tape provides bond to irregular pipe surfaces as well as moisture-proof seal at helix or spiral whether applied with or without adhesives, the company says.

Reilly Chemical Index containing information on over 100 organic compounds including acetylenic alcohols, fused ring heterocyclics, hydrocarbons, phenol and substituted phenols and pyridine and pyridine derivatives has been published by Reilly Tar & Chemical Corp., 1615 Merchants Bank Bldg., Indianapolis 4. Copies of 8-page index are available from the company or nearest Reilly office.

Amercoat No. 87, a vinyl mastic protective coating said to have non-volatile content in excess of 55 percent is produced by Amercoat Corp., 4809 Firestone Blvd., South Gate, Cal. Manufacturer claims coating resists most mineral acids and solvents, is unaffected by strong alkalis such as sodium hydroxide up to 50 percent, unharmed by nearly all salt solutions and has excellent water resistance. Double pass spray coat produces film approximately 10 mils thick at coverage of 50 square feet per gallon which does not flow away from edges and sharp corners, the company says. Coating must be applied over Amercoat No. 86 Primer and not directly to metal.

Permapass Stainless Steel Cleaner and Passivator for use as final treatment to remove iron contamination is manufactured by Concor Chemical Co., P. O. Box 846, Hoboken, N. J. Applied by brush, liquid cleaner is said to remove acid stains, light weld burns, rust and free iron and cleans, degreases and passivates stainless steel surfaces in one

(Continued on Page 84)

Lapel Pins



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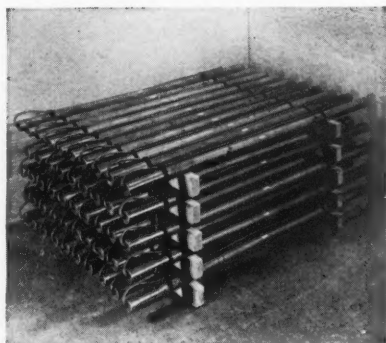
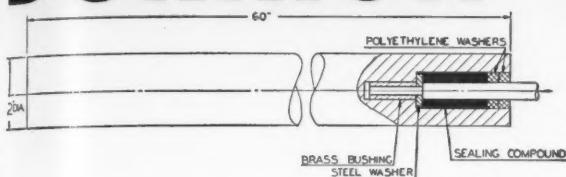
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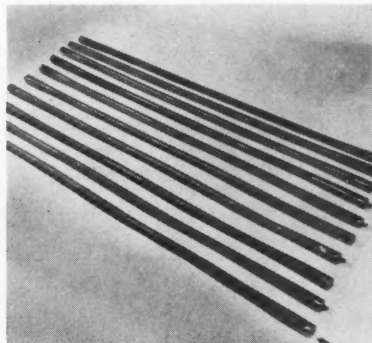
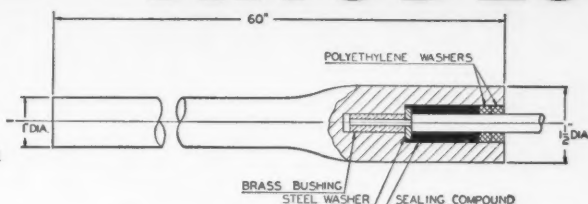
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B	1" dia. x 60" with standard lead wire of 5' No. 8 cable, 4/box.	1.4	13.6	Fresh water application. Driven connection for individual use.
C	1 1/2" dia. x 60" with standard lead wire. 4 anodes/box.	2.0	25.0	Ground bed or severe fresh water application. Driven connection.
D	2" dia. x 60" with standard lead wire. 2 anodes/box.	2.6	46.0	Sea water or severe ground bed application. Driven connection.
E	3" dia. x 60" with standard lead wire. 2 anodes/box.	4.0	115.0	Sea water application. Driven connection.

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NEW PRODUCTS

(Continued From Page 82)

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critical applications or to protect installations in corrosive atmospheres, the company says. A two-page technical bulletin on the cleaner is available from the company.

H-H Electro-Zinc Plated Domestic Evaporators with Du Pont-developed finish said to have excellent protective qualities against corrosion and abrasion are produced by the North Chicago Division of Houdaille-Hershey Corp., 1500 Fisher Bldg., Detroit 2. Evaporator's plating operation provides durable and ductile basic metal protection, its lighter weight contributes to increased operating efficiency through faster defrosting and response to load changes and integral headers are full size for peak efficiency under changing loads the company says.

Establishment of a national Aluminum Department to afford aluminum casting alloy consumers advantage of maximum service from major supplier is announced by the Federated Metals Division of American Smelting and Refining Co., New York.

A Continuous Hot-Dip aluminum coating process for iron and steel wire based on fluxing action of complex salt compounds applied to wire surface from a hot aqueous solution has been developed by Page Steel and Wire Division, American Chain & Cable Co. Inc., 929 Connecticut Ave., Bridgeport 2, Conn.

Model E-4 Detector featuring direct current, high potential output, bell signal alarm and variable adjustment and said to be adaptable to large and small pipe is manufactured by Tinker & Rasor, San Gabriel, Cal. Unit is adjustable from 2500 to 20,000 volts DC and adaptable to full and half circle electrodes, the company says.

Pipe Line pigs of spring brush type to supplement chemical solvent action and said to be especially useful in removing soft or medium-hard scales are used by Dowell Inc. a subsidiary of The Dow

Chemical Co. Pig consists of pipe length fitted with flexible rubber cups and steel brushes mounted on tempered steel springs which help to remove scale as pig is pushed through line by pumping solvents behind it. Small amount of solvent is jetted through nose of pig to prevent loosened scale from piling up in line and stopping tool. High-pressure jet mole and fill-and-soak procedure are also used by Dowell to remove scale deposits. Mole is used to jet solvents on extremely hard scales that cannot be removed by pig. On straight chemical cleaning job line is filled with solvents and allowed to soak until deposits are dissolved. Solvents are drained and line flushed with water.

Blaw-Knox Co., Farmers Bank Bldg., Pittsburgh announces integration of its Process Equipment Department, formerly at Pittsburgh into its Builovak Equipment Division at Buffalo, N. Y.

Bernard Chemical Co., 2405 W. 4th St. Los Angeles 57, produces Bar-Flame Vapor Barrier, a corrosion inhibitor which it says prevents infiltration of microscopic moisture vapors to protect steel against corrosion and corrosion creep. When applied over Bar-Flame 101, a fire-resistant coating; product shows moisture vapor transmission rate of only 0.027 grams of water vapor per square meter per 24 hours, the company claims.

An Iron-Base alloy aluminum steel is described in a report released by the Department of Commerce's Office of Technical Services. Compound contains 15 to 16 percent aluminum and approximately 3 percent molybdenum and can be fabricated into thin, flexible, cold-rolled sheets, the department said. It revealed that experiments show material's stress-rupture life could be made around 100 times that of basic binary alloy at 1200 F.

A Sheet-Aluminum slidegate for flumes reinforced with extruded aluminum angles and said to be corrosion-resistant in normal flow is produced by Rodney Hunt Machine Co., Orange, Mass. Manufacturer recommends gate where odd channel sizes are present in design, full channel flow is desirable and closure can be made under balanced conditions. Unit is controlled by manually operated bench-stand hoist with control stem.

Corning 41 Grease, a silicone fluid-carbon black mixture is described in a 6-page brochure available from Dow Corning Corp. Midland, Mich. Brochure includes performance data in form of illustrated case histories dealing with actual savings in relubrication schedules, replacement and maintenance costs. Applications discussed include oven conveyor bearings, dolly wheels, injection valves, permanent casting machines, extruder hold-down bolts and turbine governors. Specifications and typical properties are also given.

Industrial Controls, Inc., 4202 S. Owassa St., Tulsa has been appointed authorized distributor for products manufactured by Research & Control Instruments Division of North American Philips Co. Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.



Cut corrosion costs with "CORECO"

Corrosion Rectifying Company provides complete cathodic protection . . . corrosion surveys . . . soil resistance tests . . . design and installation of rectifier and anode systems . . . a full line of materials for cathodic protection.

(Continued on Page 85)

NEW PRODUCTS

(Continued From Page 84)

CI-103 and CI-104 corrosion inhibitors, said to be effective on ferrous and non-ferrous metals are manufactured by John B. Moore Corp., P. O. Box No. 3, Nutley 10, N. J. CI-103 is film former which dries tack-free in three to four minutes and may be removed by simple aromatic petroleum solvent wash whereas CI-104 is not coating or film former but leaves durable deposit of mono-molecular dimension as moisture barrier on surfaces treated, the company says. Inhibitors were developed by Princeton Paint Laboratories.

Poly-Cell, a resinous liquid sprayed like paint and said to immediately foam to 20 times original thickness is produced by Insul-Mastic Corp. of America, 1141 Oliver Bldg. Pittsburgh 22. Manufacturer claims product eliminates fitting and fastening tasks, will adhere to any clean, dry surface and to moist surfaces, will not support combustion and is one piece insulation with no joints to expand or contract. K factor is 24 per inch of thickness weighing slightly more than two pounds per cubic foot. High temperature is 225 degrees and lowest temperature at which product has been tested is -40 degrees, the company says. Product consists of two liquids blended in exact proportions and heated to specified temperature with heat retained until liquids reach gun. Spraying equipment (except conventional gun) is special type designed by the company. Company's present plans are to use own crews to apply Poly-Cell.

Carpenter 7Mo, an alloy said to have resistance to general corrosion and stress corrosion cracking is described by analysis, physical characteristics and mechanical properties in a four-page product bulletin available from Alloy Tube Division of The Carpenter Steel Co., Union, N. J. Pamphlet outlines steel's uses as well as its corrosion and oxidation resistance and provides instructions such as machining, welding, annealing, hardening and drawing. Complete size range of tubing and pipe available are listed.

Hydrocide Colorcoat, an oil-base product using silicon compounds is produced by Building Products Division of L. Sonneborn Sons, Inc. Manufacturer recommends protective finish for use on brick, masonry, cement block, cast stone or asbestos shingles and claims it provides even-textured coating on any masonry, plaster, plasterboard or properly primed surface and bonds firmly to metal. Finish can be brushed on with stiff nylon or fibre brush or with conventional whitewash or acid brush and spraying equipment may be used. Other advantages are application in stages without causing lap marks, ability to withstand extreme temperature changes without cracking or peeling and elimination of wetting wall before and wet-curing after application, the company says.

Vibroground portable field instruments for measurement of ground resistance and soil and earth resistivity are described in Revised Bulletin 1-2 available from Associated Research, Inc., 3750 W.

(Continued on Page 86)

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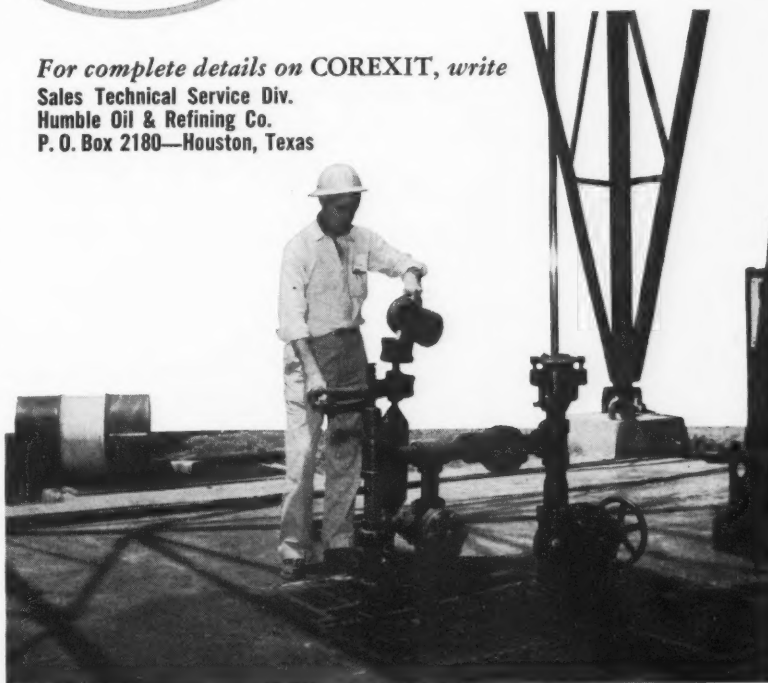
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NEW PRODUCTS

(Continued From Page 85)

Belmont Ave., Chicago 18. Application in checking resistance to ground of grounding rods, grids and structures; measurement of soil resistivity in conjunction with corrosion control and cathodic protection studies and earth resistivity measurements for geophysical prospecting are covered in the eight-page bulletin which also includes instructions and schematic diagrams illustrating proper field application.

Michigan Pipe Co. announces relocation of its Bay City operations in its new plant in Gagetown, Mich. Firm manufactures wood-lined steel pipe, thermoplastic lined pipe and wood stave pipe under trademark MPC.

Chemi-Drain Channel Pipe, a vitrified clay product for handling and disposal of corrosive industrial wastes is described in a four-page illustrated circular available from The Logan Clay Products Co., Logan, Ohio.

Cooling Tower units said to save more than 95 percent of water used in industrial plants for cooling compressor jackets and inter- and after-coolers are described in 16-page catalog (WT & CT-583) available from Halstead & Mitchell, Bessemer Bldg., Pittsburgh. Operating characteristics, specifications, selection and installation of 20 commercial cooling towers ranging in capacity from five through 60 tons with tables, drawings and graphs are included. Information also provides cooling tower nominal table for 78 and 75 degree wet bulb temperatures, outlet water temperature plotted against wet bulb temperature, tower capacity plotted against wet bulb temperature, layout for year-round operation and inside use and other data.

Met-L-Flex, an all-metal, plate-type shock mount said to withstand dynamic loads as great as 50 "G" and static loads greater than 100 "G" is manufactured by Robinson Aviation, Inc., Teterboro, N. J. The load is carried entirely by knitted stainless steel wire mesh cushions. Manufacturer claims protection is unimpaired regardless of exposure to temperature extremes, oil grease, water, dirt or solvents and performance will not change because cushions do not age, wear out or pack down.

Ampco-Trode 46, a nickel-aluminum bronze alloy available as covered electrodes for metal-arc and 36-inch bare filler rods for carbon-arc welding of castings of similar nature are described in Bulletin 54L-148 available from Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 46. Three-page bulletin includes information such as product identification, chemical composition, mechanical properties, current recommendations with various processes and welding procedure.

Controlled-Capacity proportioning pumps known as Phila-Feeder are manufactured by Philadelphia Pump and Machinery Co., a subsidiary of American Meter Co., 1513 Race St., Philadelphia. Manufacturer claims product is designed for all general water treating requirements and emphasizes simplicity, durability, dependability and ease of maintenance. Features include packing gland with external no spring adjustment for positive packing compression, steel cross head running in precision machined bronze guide, forged or stainless steel liquid end, ground and polished stainless steel piston, hardened and ground stainless steel valve balls, springloaded for instant response, hardened connecting rod bearings and ground pins running in grease-lubricated needle bearings and one-piece heavy channel steel base plate, the company says. Catalog LP-1254 describing pumps is available from company.

Scotch Brand pressure sensitive tapes are described in a 56-page manual available from Minnesota Mining and Manufacturing Co., 900 Fauquier St., St. Paul 6. Manual contains 331 illustrations showing how 47 tapes can be used in metalworking industry. It is divided into sections covering tapes uses for machining and finishing, electroplating, stamping and fabricating, welding, product assembly, painting, product promotion, packaging and shipping, plant maintenance and various miscellaneous operations. Also special sections are devoted to office uses, engineering and development services and properties of tapes.

A Rust Inhibitive protective coating in spray bomb form called Totrust Instant Dry Metal Coat is manufactured by The Wilbur & Williams Co., 130 Lincoln St., Boston 35. One coat penetrates and stops rust and dries in less than five minutes to durable, ready-for-use coating, the company says. It may be used on rusted or damp metal surfaces, painted or unpainted, indoors or out including aluminum and galvanized metal, the company claims.

Non-metallic, dustless Mono-Kleen mineral shot for blast cleaning are described in a four-page technical bulletin available from Baldwin-Hill Co., 500 Breunig Ave., Trenton 2.

Unichrome Plastisol Compound 4129, said to offer economical and attractive protective coating against abrasion and corrosion due to humidity, moisture and foodstuffs is manufactured by Organic Coating Division of United Chromium, Inc., 100 E. 42nd St., New York 17. Thixotropic properties of the cold-dip compound make possible approximately 50 percent less material deposit and increased application speeds with optimum film unity than can be obtained with other plastisols, the company says. Manufacturer claims coating is cured by baking at 350 to 365 F for 20 to 30 minutes.

Two Thread and antiseize compounds with sealants and lubricants composed of flake copper powder, lead and zinc dust and graphite powder are produced by Metachem Laboratories, Inc., Hammond, Ind. API High Pressure Thread Compound containing approximately 15 percent silicone fluid in vehicle is designed for pressure work up to 10,000 psi on extremely critical points where unusual metal adhesion or moisture penetration properties are required, the company says. Plastimet, a general purpose compound without silicones in vehicle forms metallic coating on line and sheave to protect these from wear and corrosion, the company claims. This product also eliminates use of gaskets on reasonably flat surfaces and can be used on all types of pipe line connections, including air, gas, water, steam, hydrocarbon chloride or other chemical lines, the company said.

Wemco Metal Pump for transferring molten metal or salts is produced by Wire Equipment Manufacturing Co., Inc., 1168 S. Olden Ave., Trenton 10. Maximum rated capacity of pump in zinc is 360,000 pounds per hour and manufacturer recommends temperature limitations on pure zinc to 860 F, lead (Metal type, etc.) to 1700 F, pure aluminum.

(Continued on Page 88)

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NEW PRODUCTS

(Continued From Page 86)

minum to 1450 F and salts (all non-alloying materials) to 1700 F. When used to drain pan or kettle at first sign of developing leak, product enables immediate shut-down of burners and strips pan before metal solidifies, the company claims. Pump is powered by 3 hp air motor consuming 90 cfm at 80-90 psi at full capacity and regulated by controlling air input to motor.

Protektinsul, a prefabricated Krene plastic cover, said to protect thermal insulation on pipe and ducts against weather, abrasion, moisture and most chemicals and to withstand corrosive atmospheres and electrolytic corrosion is manufactured by Miracle Adhesives Corp., 214 E. 53rd St. New York 22. Cover is wrapped around insulated pipe and closed by pulling plastic slide fastener which locks pre-formed edges together, holds cover in place and completes seal around pipe. End joints or fittings in line are wrapped with Krene plastic tape. Coating based on Bakelite vinyl resin is brushed on to seal fitting cover. Manufacturer recommends use of product on insulated pipe indoors and outdoors, underground in steam-distribution system of conduits or on low-pressure building heat supply lines.

A Fluorothene (generic name for polymers of monochlorotrifluoroethylene) said to resist heat up to 390 F and virtually all acids, alkalis and solvents including aqua regis, strong caustics and vigorous oxidizing materials such as nitric acid is produced by Bakelite Co., a Division of Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17. Manufacturer claims product behaves principally like rigid thermoplastic with tensile strength of these plastics but has compressive strength of 32,000 to 80,000 psi (annealed) making it useful for tower packings, valve sets and for diaphragms and impellers on pumps. Because of low dielectric constant and high dielectric strength product is used to mold electrical parts such as insulators, conductivity cell components, rectifiers and switch bodies, the company says. It can be punched and drilled and otherwise machined to close tolerances which make it useful for intricate molded items, the company states.

Man-Made crystalline zeolites for use as selective adsorbents are produced by Linde Air Products Co., a Division of Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17. Manufacturer claims adsorbents, called molecular sieves, can separate mixtures of gases or liquids on basis of difference in molecular size where heretofore difference in boiling point has been primary factor in selective adsorbents and show marked affinity for polar and unsaturated molecules adsorbing these in preference to non-polar molecules of same size. Separation by distillation of two materials with approximately identical boiling points is possible if one is small enough to pass through pores of one of the molecular sieves and simultaneous adsorption of other impurities along with water is possible, the company says. It revealed that sieves can be regenerated readily by combination of heating and

purging and that they will adsorb water at temperatures as high as 212 F.

Flip Seal UL-approved electrical connectors produced by Rodale Manufacturing Co., Inc., Emmaus, Pa., are said to seal out moisture, dirt, dust, metal particles and other conditions which tend to interrupt flow of current. Connector components are molded of phenolic plastic and encased in rubber or neoprene housing. Flexible rubber lip incorporated over female component of connector flips over male component to insure positive sealing and locking type action and cable entrances fit snugly around wire because both ends of connector are provided with sealing action, the company says. Submerging product in tank of brine for one week and shooting current through it produced no ill effects or impairment of effectiveness, the company revealed.

Shurclose Caps and Plugs, rubber and plastic protective closures for threaded parts, pipe and tubing ends are produced by Ray A. Sharer and Co., 3000 E. Grand Blvd., Detroit 2. Manufacturer recommends product for use to protect threaded openings and connections against possible damage, prevent moisture or dust penetration, seal in gases and liquids and mask pipe or tube ends from paint spray and preservative finishes. Rubber closures are made of high-grade, sulfur-free, black rubber or, if required, of neoprene, hycar or natural rubber. Plastic closures are molded vinyl or polyethylene which are impervious to practically all commercial gases and fluids and do not chip, shred or break under severe usage, the company says.

Granodraw zinc phosphate coatings said to increase corrosion-resistance during storage, improve finish, increase amount of possible reduction and production, lower percentage of rejected work and make possible less "down time" of machines is produced by American Chemical Paint Co., Ambler, Pa. A 300 to 400 percent increase in tool life by use of product over other methods of lubrication such as lime, borax or silt coat is claimed by the manufacturer. Product has proved effective in preventing galling and scratching and resists metal-pickup, the company says.

An Industrial Pycnometer machined from solid acrylic plastic and designed for industrial operations to check weight per gallon or specific gravity of viscous material and corrosive liquids is produced by Gardner Laboratory, Inc., Bethesda, Md., using Plexiglas, an acrylic plastic, made by Rohm & Haas Co., Washington Square, Philadelphia 5. Tare weight, is also machined from Plexiglas with close side clearance permitting it to settle slowly to bottom of cup. When used cup is filled just over fill-line engraved inside lip and fitted cover placed on top to squeeze liquid out through hole in center. After excess is removed, cup is placed on balance and its weight counterbalanced with tare. Contents are weighed to nearest 0.1 gram and weight in grams, divided by 10, gives weight per gallon in pounds.

Sintered Bronze filters, said to be virtually unaffected by temperature extremes and corrosive liquids and gases are described in a 16-page catalog avail-

able from Permanent Filter Corp., 1800 W. Washington Blvd., Los Angeles 7.

Galvomag, a magnesium anode material said to supply 20 to 30 percent more current than other conventional magnesium anode alloys is produced by The Dow Chemical Co., Midland, Mich. Product's advantages include fewer installations thus reducing total protection costs and high potential gives protection in the higher resistivity soils, the company says.

CI-88, a black, anti-rust paint said to afford low cost protection of exterior work is manufactured by Chem Industrial Co., Brooklyn 9, Ohio. It incorporates a bituminous base with special paint vehicle to produce heavily bodied coating which can be applied by brush, spray or dip on outside metal after minimum surface preparation, the company says. Manufacturer recommends product for use on such items as building trim, utility poles, tanks, pilings, machinery and stacks.

Hypco Engineering, Inc. has moved its offices to 700 39th Ave. N. E., Minneapolis.

Chemical Analyses of standard carbon, alloy and stainless steels used in elevated temperature and/or pressure service tubing are covered in four-page data folder TDC 177 available at no cost from general sales offices of Tubular Products Division of The Babcock & Wilcox Co., 161 E. 42nd St., New York City. Folder is cross-indexed to associate grade and ASTM specifications for individual tubing steels involved and lists ASTM tubing and pipe specifications by number and title for ready reference.

Surfamax stainless steel filters with porous stainless steel elements are described in Bulletin 213 available from Micro Metallic Corp., 30 S. Cliff Ave., Glen Cove, New York. Information on choice of filter area, porosity of porous stainless steel filter elements, pressure ranges, pipeline fittings and element spacing is provided and recommendations on filter use and indicated applications are included.

Durco Type M and Type N valves, redesigned high silicon iron Y and Angle valves that include corrosion resistant Durion or Durichlor are covered in a two page Bulletin V/8 published by The Durion Co., Inc., Dayton.

Polyethylene seamless ducting, duct fillings, exhaust hoods, centrifugal fans, weather caps and other components for installing ventilating and exhaust systems are covered in an eight-page brochure available from the American Agile Corp., P. O. Box 168, Bedford, Ohio.

Engineering Properties and Applications of Ni-Resist, a corrosion resistant nickel alloyed cast iron, is title of the 64-page Bulletin A-71 available from the Customers Service Bureau, The International Nickel Co., Inc., New York 5. Booklet tabulates mechanical and physical properties offered by the eight types of Ni-Resist. Problem data sheets for submitting heat, corrosion or controlled expansion problems to development and research staff are included as well as 15 tables and charts and 96 figures.

(Continued on Page 90)



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NEW PRODUCTS

(Continued From Page 88)

The Ruud-Alcoa Alloy automatic water heater, an aluminum tank, gas fired heater, is produced by Ruud Manufacturing Co., Pittsburgh. Tanks do not introduce rust into water, make benefits of solid aluminum tank available at cost comparable to glass or enamel-lined tank and are designed for operation with all natural, mixed, manufactured and LP gases, the company says.

F-4141, a water-dilutable treatment said to be easily applied to give maximum resistance to glass, porcelain and china is produced by Dow Corning Corp., Midland, Mich. Manufacturer claims material is instantly effective in concentrations as low as 0.01 to 0.1 percent and can be applied by dipping, flooding or spraying with conventional equipment. Optimum properties are developed by air-drying at room temperatures for 24 hours or by curing for 10 minutes at 100 C, the company said. It claims that cured film is not affected by two hour exposure to live steam, perchlorethylene or three percent sodium chloride and although water repellent treated surfaces may be labeled with many resin-type inks and certain adhesives.

Dangers of Steam Contamination and how to prevent or correct them are outlined in a six-page folder entitled *Steam Purity*, available from Hall Laboratories, Inc., 323 Fourth Ave., Pittsburgh 22. Various types of carryover are discussed along with value of antifoams in stopping these. Actual examples are provided where impure steam resulted from leakage of soap, gray and flavoring material into steam and condensate systems.

PERSONALS

Ross E. Schofield has been named district representative in charge of the Houston sales office of the Beryllium Corp., Reading, Pa.

Robert M. Wilson, Jr., has been assigned as a development engineer in the power field Development and Research Division of The International Nickel Co., Inc., 67 Wall St., New York 5.

Lea P. Warner has been appointed assistant to the president and **John R. Roberts** as sales manager for Quelcor, Inc., Chester, Pa.

The following changes and promotions are announced by the Atlas Mineral Products Co., Mertztown, Pa.: **Joseph A. Snook**, executive vice president; **Eugene Kirkpatrick**, general sales manager; **George Gabriel**, manager of manufacturing; **Gerald F. Gilbert, Jr.**, treasurer and purchasing agent; **George L. Wirtz, Jr.**, manager of product planning and **Kenneth T. Snyder**, assistant sales manager.

Edward M. Welty has been named district manager of the Cleveland office of the H. M. Harper Co., Morton Grove, Ill.

F. W. Gartner, Jr., has been appointed partner to **G. W. Gartner, Sr.**, of F. W. Gartner Co., 3805 Lamar Ave. Houston. He will act as manager of general operations for the company.

Charles J. Gregg, 71, retired Appalachian district sales manager with Dresser Industries, Inc., Bradford, Pa., died recently at his home in Bradford. He had been with the company 43 years prior to his retirement in 1948.

Rear Admiral Wilson D. Leggett, Jr., USN, chief of the Navy's Bureau of Ships has been named vice president of engineering of American Locomotive Company. His appointment will become effective upon his retirement from the Navy on March 31.

George S. Forbes has been appointed field manager of national industrial sales for The Glidden Company. He will work with Thomas N. Armel, Glidden's general manager of industrial sales in supervising all phases of Glidden's industrial coating business, industrial maintenance sales, and transportation business.

Benjamin S. Mesick has joined the staff of Arthur D. Little, Inc., 30 Memorial Dr., Cambridge, Mass. His chief responsibilities will be to expand the company's activities in the titanium fabrication field.

W. F. Munnikhuysen has been elected chairman of the board and **Fred C. Foy** named president and chief executive officer of Koppers Co., Inc., Pittsburgh. **R. R. Holmes** was elected vice president and general manager of the company's Tar Products Division succeeding Mr. Foy.

Ray Cherry has joined the Houston office engineering staff of Catholic Protection Service.

Paul M. Barnes has been named export sales supervisor of Acheson Colloids Co., Port Huron, Mich.

O. Müller-Habig has been appointed president of Centrico, Inc., Englewood, N. J.

T. H. Daugherty has retired as research director of Calgon, Inc., after 21 years of service. He will continue as consultant. **Ralph N. Thompson** has been named research manager for Calgon and Hall Laboratories, Inc., chemical subsidiaries of Hagan Corp., 323 Fourth Ave., Pittsburgh.

Kenneth A. DeLonge has been placed in charge of the Iron and Non-Ferrous Castings Section of the Development and Research Division of The International Nickel Co., Inc., 67 Wall St., New York 5.

Kent R. Van Horn, director of research for Aluminum Company of America has been elected to an honorary life membership in the Society for Nondestructive testing.

Russell B. Barnett has been elected president of Peter A. Frasse and Co., Inc. **Theodore W. Hager** was named vice chairman of the board for the company.

Dr. Vannevar Bush, president of the Carnegie Institution of Washington, was awarded an honorary membership in The American Society of Mechanical Engineers during ASME's Founding Anniversary Meeting held at the Hotel Statler in New York City on February 16.

T. J. Cox has been appointed assistant general manager of Wheeling Steel Corporation's Ackermann Factory located in Wheeling, West Virginia.

The Bristol Co. Waterbury, Conn., has named **John M. Maitland** as manager of its Detroit District Office.

John H. Conroy has been named sales director for Shilstone Testing Laboratory, 2301 W. Dallas Ave. Houston 19.

William A. Damerel has been named vice president and Fred Schulman as assistant director of research of the Mercast Corp., 295 Madison Ave. New York 17.

Robertshaw-Fulton Controls Co. announces retirement of **Samuel R. Simpson**, assistant vice president of the company.

John J. Hennessy has been appointed controller of R. M. Hollingshead Corp.

A. F. Anzlovar has been named vice president of the Mercast Manufacturing Corp. LaVerne, Cal., a subsidiary of the Mercast Corp., 295 Madison Ave., New York 17.

F. A. Gilbert has been named vice president and assistant division manager, **J. F. Shea**, vice president in charge of sales and **W. J. Wetzel**, controller of the Becco Chemical Division, Food Machinery and Chemical Corp. Buffalo, N. Y.

Retirement of chief metallurgist **Edward B. Story** is announced by A. M. Byers Co., Pittsburgh. He is retained in capacity of consultant. **E. P. Best** is named to replace Mr. Byers as chief metallurgist at the company's Ambridge plant. **Harry R. Rowland** has been appointed general manager of sales and **Edgar L. Fix** manager of steel sales for the company.

Les Spohr, formerly with General Chemical Division, Allied Chemical & Dye Corp., East St. Louis, has been appointed St. Louis representative for Prufcoat Laboratories, Inc., 50 E. 42nd St. New York 17.

George F. Sharrard has been appointed manager of the Technical Service Division, R. M. Hollingshead Corp.

Rudolph A. Fenoglio has been named assistant plant manager of the Maywood, Indianapolis, multiple plant operation of Reilly Tar & Chemical Corp.

Eugene Easterly has been appointed vice president of Distribution and E. G. Hickling as vice president of Operations of Linde Air Products Co., a Division of Union Carbide and Carbon Corp.

A. M. Davis, former chief production engineer of A. V. Roe, Canada, Ltd., has been named chief engineer-power plants of the power plants division, Marquardt Aircraft Co., Van Nuys, Cal.



Index to CORROSION ABSTRACTS

Vol. 11	May, 1955	No. 5
1. GENERAL		
1.4 Bibliographies	91	Page
1.7 Organized Studies of Corrosion	91	7992
2. TESTING		
2.3 Laboratory Methods and Tests	91	
3. CHARACTERISTIC CORROSION PHENOMENA		
3.2 Forms	92	
3.4 Chemical Effects	92	
3.5 Physical and Mechanical Effects	92	
3.6 Electrochemical Effects	94	
3.7 Metallurgical Effects	94	
5. PREVENTIVE MEASURES		
5.3 Metallic Coatings	94	
5.6 Packaging	98	
5.7 Treatment of Medium	98	
5.9 Surface Treatment	98	
5.10 Other	102	
5.11 Design-Influence on Corrosion	102	
6. MATERIALS OF CONSTRUCTION		
6.2 Ferrous Metals and Alloys	103	
6.3 Non-Ferrous Metals and Alloys—Heavy	104	
6.4 Non-Ferrous Metals and Alloys—Light	110	
6.6 Non-Metallic Materials	110	
6.7 Duplex Materials	112	
7. EQUIPMENT		
7.1 Engines, Bearings, and Turbines	113	
7.2 Valves, Pipes and Meters	114	
7.3 Pumps, Compressors, Propellers and Impellers	114	
7.4 Heat Exchangers	115	
7.5 Containers	116	
7.6 Unit Process Equipment	116	
7.7 Electrical—Telephone and Radio	118	
7.8 Wires and Cables (Non-Electrical)	119	
7.10 Other	119	
8. INDUSTRIES		
8.1 Group 1	120	
8.3 Group 3	120	
8.4 Group 4	120	
8.5 Group 5	124	
8.7 Group 7	124	
8.8 Group 8	124	
8.9 Group 9	126	

1. GENERAL

1.4 Bibliographies

1.4, 3.1, 5.1
Corrosion. A Bibliography of Unclassified Report Literature. ROBERT E. ALLEN, comp. Technical Information Serv-

ice, Atomic Energy Commission, TID-3048, June, 1954, 55 pp.

This annotated bibliography contains 214 references citing corrosion data found in the unclassified reports held by the Technical Information Service, Oak Ridge, as of January 1, 1954. Author, subject, and report number indexes are included.—NSA. 7992

1.4, 6.5, 3.1, 5.1

Unclassified Bibliographies of Interest to the Atomic Energy Programme. P. E. POSTELL AND H. E. VOESS. U. S. Atomic Energy Commission Publ., (TID-3043), 1953, 56 pp.

A compilation of 693 bibliographies. Metal topics covered include the following: aluminum alloys; the metals barium, beryllium, cobalt, copper, hafnium, iron, lithium, lead, magnesium, manganese, molybdenum, niobium, rhodium, ruthenium, selenium, silicon, tantalum, thorium, titanium, tungsten, zinc, zirconium; borides; centrifugal casting; corrosion; creep; crystal plasticity; electrodeposition; electron microscopy; electroplating; fatigue; furnaces; gallium alloys; heat transfer; metal hydrides; oxides; power metallurgy; preferred orientation; refractories; rolling; thermal analysis and conductivity; thermometry; welding.—MA. 7862

1.7 Organized Studies of Corrosion

1.7.1, 3.2.1

Identification of Corrosion Products According to Crystal Structure Underway. C. E. IMHOFF. *Corrosion*, 9, No. 7, 209 (1953) July.

A brief report on the work of the Technical Practices Committee on the identification of corrosion products. The committee proposes to collect and correlate data on corrosion products identified according to crystal structure, and it will identify diffraction patterns by correspondence. A list of positively identified corrosion products is given.—ZDA. 8004

2. TESTING

2.3 Laboratory Methods and Tests

2.3.6

How to Use Micro-Interferometry as a New Chemical Engineering Tool. R. E. SUGG. *Chem. Eng.*, 61, No. 3, 216-217 (1954) March.

The micro-interferometer (first developed by Michelson, though first published description was by Linnik in 1933) is especially suited to examination of surface finishes on metals and to other problems for micro-contour measurements. Thus the instrument permits of the detection of rough spots only 1 millionth of an inch high in scratches

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left in the finishing operation on a polished metal surface. The present article is quite short and gives little detail.—BNF. 7958

2.3.6, 2.3.9

The Application of Colour Micrography by Forming Thin Epitaxial Films in Interference Colours for Studying Aluminium, Iron and Copper. (In French). P. LACOMBE AND M. MOUFLARD. *Metalux: Corrosion-Industries*, 28, No. 340, 471-488 (1953) December.

General methods which develop colors on isotropic and anisotropic metals are discussed in the first part of the present report. The principles of color microscopy are described with special regard to the three main methods based on interference, polarization and etching. In the second part the application of thin films on aluminum, copper and iron is shown. Color microscopy allows investigation of the metal structure. Changes in the metal by casting, cold hardening, recrystallization as shown by color microscopy are discussed and illustrated by a number of photographs. It is possible to make visible small concentration differences in solid solutions or impure metals where the grain boundaries and it is possible to study the daries are shown by difference in colors. Even smaller structural differences are made visible such as solidification den-

nuclei forming role of the old crystal boundaries. The forming of fine epitaxial films on the metal presents an extremely sensitive control on the geometric or chemical condition of the metal surface.—ALL. 8041

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 4.6.2, 6.2.4, 6.2.3

Segregated Graphite in Steel J. J. KANTER, Crane Co. Eng. Labs. Paper before API, Div. Refining, 18th Mid-Year Mtg., Session on Deterioration of Metals, N. Y., May 11, 1953. *Proc. Am. Petroleum Inst.*, 33, Sect. III-Refining, 225-229 (1953).

Piping structures of carbon and carbon-molybdenum steels in steam service at high pressure and temperature are liable to develop segregated graphite at the heat-affected zones of welds. Segregation of graphite appears to be related to localization of plastic strain. Graphitization leads to loss of ductility when the factors determining segregation are active. Inspection for graphitization deterioration must evaluate the ductility loss rather than the mere presence of graphite; randomly distributed graphite is not necessarily hazardous. Susceptibility to graphitization is related to steel-making practice and the use of aluminum for deoxidation or killing is vitally involved. When graphite segregation must be avoided, chromium-molybdenum steels are used. Steels alloyed singly or in combination with elements such as molybde-

num, manganese, nickel, vanadium or titanium have been demonstrated to undergo graphitization.—INCO. 7961

3.2.2, 5.3.4

Hydrogen Embrittlement of Steel During Electroplating. II. Zinc Electroplating. U. TRAGARDH, *Iva* (Stockholm), 24, 53-71 (1953); *Chem. Abs.*, 47, No. 17, 8558 (1953) Sept. 10.

Describes the deposition of zinc from various electrolytes on three spring steels that were very similar in composition and in mode of production but very dissimilar as regards hydrogen embrittlement. A detailed description is given of the pickling procedure, the composition of the electrolytes used and the measurements made.—ZDA. 7938

3.2.2, 5.9.4, 6.2.5

Nitriding of Austenitic Chromium-Nickel-Molybdenum Steel Tubes by Nitrogen in Internal Pressure tests at 700°C. F. BRAUMANN AND H. KRACHTER. *Arch. Eisenhüttenw.*, 25, 373-375 (1954) July/Aug.

Chemical, metallographic and X-ray investigations on the nitrided layer on inner surface of tubes of a 9.6% nickel, 17.4% chromium, 2.6% molybdenum, 0.6% titanium and 0.1% carbon steel, after exposure for 10,000 hours to high-pressure nitrogen at 700 degrees. Nitrogen content in nitrided layer was 2.2% at conclusion of exposure, as compared with initial content of 0.017%. The layer is brittle and may exhibit fine hairline cracks. In addition to the austenitic matrix, there are present in the layer an iron-chromium mixed nitride and an almost pure epsilon phase of iron nitride Fe_2N .—INCO. 8034

3.2.3, 3.8.4

Comparative Study of the Mechanism of the Oxidation of the Binary Alloys Iron-Chromium, Nickel-Chromium, and Nickel-Aluminum. (In French). JEAN MOREAU AND JACQUES BENARD. *Compt. rend.*, 237, No. 22, 1417-1419 (1953).

The experiments of Moreau [*ibid.*, 236, 85 (1953)] on the binary iron-chromium alloys were applied and extended to the alloys nickel-chromium (0-10% chromium) and nickel-aluminum (0-5% aluminum). The specimens were oxidized in air at temperatures from 800 degrees to 1300 degrees C and examined by X-ray diffraction and by micrography on polished sections. A reaction common to all three alloys was observed and three regions were distinguished: 1) in the interior of the metallic phase in the immediate vicinity of the surface, a mixed metal-oxide layer composed of granules of chromic oxide dispersed in pure nickel; 2) an intermediate 2-phase region, consisting of granules of nickel chromite ($NiCr_2O_4$) having the cubic structure of spinel ($a = 8.30$ Å), dispersed in a matrix of nickel oxide ($a = 4.17$ Å); and 3) in contact with the atmosphere, a region composed of pure nickel oxide. The nickel-aluminum has an analogous morphology.—MA. 7915

3.2.3, 7.7, 6.3.10

High-Temperature Corrosion in Nickel-Chromium Alloys. NORMAN SPOONER, JOHN M. THOMAS, AND L. THOMASSEN. *J. Metals* (Trans. AIME), 5, No. 6, 844 (1953).

A brief report of a study of the phenomenon of "green-rot," which is often encountered when nickel-chromium and nickel-chromium-iron alloys are used as electrical resistance heating elements in reducing atmospheres. Although little

success was obtained in producing severe corrosion when commercial 80-20 nickel-chromium alloys were heated in various reducing atmospheres, it was found that these and 90-10 nickel-chromium wires deteriorated very rapidly when placed in the bottom of narrow thermocouple protection tubes and heated in air. 90-10 alloys heated with an abundant air supply became coated with an oxide layer consisting of both nickel and chromium oxides (i.e. thermodynamic equilibrium between the oxides was not established), which on subsequent heating at 1500-1800 F (815-985C) inside small-diameter tubes became transformed to a bright metallic outer layer of nickel or nickel-rich alloy, beneath which appeared a green oxide, followed by intergranularly attacked metal, the obvious explanation being that thermodynamic equilibrium had become established according to the equation: $NiO + Cr$ (in alloy) $\rightarrow Ni + Cr_2O_3$. This reaction is favored by the fact that the oxygen pressure over nickel oxide is more than 10^{10} times that over the green chromic oxide. A confirmation of the occurrence of the reaction was obtained by heating oxidized nickel foil along with a piece of bright 90-10 alloy ribbon for several hours in an evacuated quartz tube, when the nickel oxide on the foil was completely reduced to pure nickel, leaving a bright foil, while the alloy ribbon became strongly magnetic and showed the green-rot structure. Thus, although many conditions becloud the green-rot phenomenon, such as carburization, sulfidization and the presence of other corrosive agents, the experiments show that the basic reaction is a case of internal oxidation due to oxygen depletion.—MA. 7909

3.4 Chemical Effects

3.4.2, 3.2.3

Catalytic Corrosion. (In Russian). S. Z. ROGINSKII, I. I. TRET'IAKOV, AND A. B. SHEKHTER. *Doklady Akad. Nauk, SSSR*, 91, No. 4, 881-884 (1953) Aug. 1.

Discusses external effect of catalytic and sorption corrosion on surface structure. Table, micrographs. 7 references. 1 plate.—BTR. 8042

3.5 Physical and Mechanical Effects

3.5.3

Influence of Slit Streams on the Intensity of Cavitation Erosion. (In Russian.) K. K. SHAL'NEV. *Doklady Akad. Nauk SSSR*, 91, No. 5, 1043-1045 (1953) August 11.

Erosion of a lead plate set up by stainless steel or brass cylinders of various dimensions, in or near to the plate.—BNF. 7886

3.5.8, 1.6, 3.8.4

Determination of the Presence and Influence of an Anodic Phase Under Conditions of Applied Stress. Final Report Covering Period November 27, 1951 to September 30, 1953. The Stress Corrosion of Brass and Some Other Alloys by the Smith and Pingel Method. J. M. DUOY AND R. L. PIGFORD. Delaware Univ., Contract DA-36-034-ORD-694, November 16, 1953, 102 pp.

Introduction of a trace of zinc chloride to the solution permits a steady potential to be obtained by a zinc spec-

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men in contact with a potassium chloride solution. A grain boundary of zinc was found to be anodic to the adjacent grain by 58.6 mv, based on a single pair of measurements. The potential of cartridge brass varies erratically in the presence of air, even when traces of cuprous chloride, cupric chloride, or zinc chloride are introduced. In the absence of air, the potential of brass varies regularly and generally increases initially after a short decrease, reaching a steady value. This steady value is a function of the location on the specimen, being different metal grains. The grain boundary is anodic with respect to the grains. More cathodic potentials of the order of 0.25 v., often observed after prolonged exposure of the metal, correspond to the oxidized metal (presence of corrosion products). More anodic potentials of the order of 0.7 v correspond to the fresh metal, but lower potentials are observed for some grains even when they are oxide free. Application of external stress does not have much direct effect on the surface potential. The stress probably acts indirectly by breaking the protective oxide film at weaker points (generally grain boundaries) where fresh, highly anodic metal appears. This causes acceleration of corrosion usually intergranular in nature. The present report gives support to the film theory of stress corrosion. The Smith and Pingel method gives satisfactory results, provided oxygen is thoroughly eliminated from the specimen, the solution and the surrounding atmosphere. (auth)—NSA. 7942

3.5.8, 2.3.7, 1.6

A Fundamental Investigation of Fretting Corrosion. H. H. UHLIG, I. MING FENG, W. D. TIERNEY, and A. McCLELLAN, U. S. National Advisory Committee for Aeronautics, Tech. Note 3029, 1953, 52 pp.

The report consists of: a) a description of a test machine for measuring fretting damage under a maximum load of 27,000 lb./in.², at frequencies of motion of 56-3000 cycles/minute and relative slip of 0-0.008-inch; b) experimental data for SAE 1018 steel in air and in nitrogen; and c) a suggested theory for the mechanism of fretting corrosion. 32 references.—MA. 7979

3.5.8, 5.11

Why Parts Fail. J. A. BENNETT AND G. W. QUICK, *Product Eng.*, **25**, No. 8, 129-134 (1954) August.

Static and overload fractures, fatigue fractures and stress corrosion cracking are the most common types of service failures. Twelve examples show service failures caused by: Use of the wrong material, decarburization that reduces strength, fretting between parts and other causes. Also included are some precautions that should be considered in the design, fabrication and use of metal parts to reduce service failures. Illustrations are given of stress corrosion cracking of aluminum alloy tubing and 24S aluminum hinge fitting. 7 references.—INCO. 8031

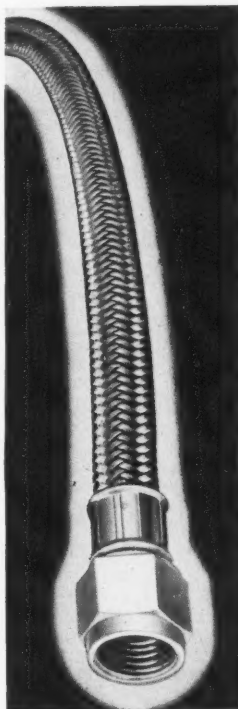
3.5.8, 6.3.6

Stressed Alpha Brass in Sea Water and Ammonia. A. R. BAILEY AND W. H. LOWTHER, *Metal Ind.*, **85**, No. 7, 126-127 (1954) August 13.

Relationship between marine environment and stress-corrosion cracking of α -brass was investigated. Results showed that neither 3 percent sodium

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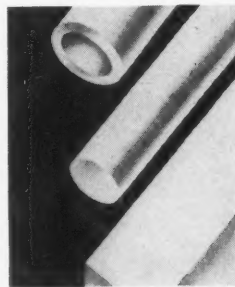
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chloride solution nor ordinary sea water are likely to cause stress-corrosion cracking of α -brass. However, the presence of small amounts of ammonia in the solution will rapidly produce cracking and with greater activity than likely by the same strength of ammonia in water alone. 21 references.—INCO. 8006

3.5.8, 6.3.6

The Energy State of Fatigued Copper. B. WELBER AND R. WEBER. *J. Metals* (Trans AIME), Section 2, 5, No. 11, 1558-1559 (1953) Nov.

As strain hardening is supposed to accompany the process of fatigue, the fatigued metal should contain stored energy, but tests on OFHC copper indicate no stored energy.—BNF. 7952

3.5.8, 6.3.6

Coefficient of Friction and Damage to Contact Area During the Early Stages of Freting. 1. Glass, Copper, or Steel Against Copper. DOUGLAS GODFREY AND JOHN M. BAILEY, Lewis Flight Propulsion Lab. Nat'l. Advisory Comm. Aeronaut., Tech. Note No. 3011, Sept., 1953, 23 pp.

Experiments were conducted to measure the coefficient of friction, μ and to determine the damage to the contact area during early stages of fretting of copper at a frequency of 5 cycles/min. Specimen combinations of copper against glass, copper against copper and copper against steel, as well as various copper oxide films and powder compacts, were used. The results lead to the conclusion that fretting of copper starts with the same mechanical damage that occurs during unidirectional sliding. Fretting of copper against glass, copper against copper and copper against steel starts with adhesion and metal transfer (galling) with accompanying high μ values (>1.0) the same as those obtained during unidirectional sliding. After the initial high values of μ , a reduction in μ was observed, associated with reduced plowing and an increasing concentration of debris in and around the contact area. After approximately 100 cycles of fretting, μ reached a constant value (0.5 to 0.6) approximately the same as that obtained with compacts of either Cu_2O or CuO . Presence of preformed Cu_2O or CuO films on copper only lower the initial coefficient of friction.—NSA. 7931

3.5.8, 6.3.6, 3.7.3

1) **The Presence of Preferential Attack in Micro-Domains in a Polycrystalline Solid Solution of Copper-Zinc Slightly Deformed Under Tension; 2) The Evolution of the Micro-Structure of a Solid Solution of Copper-Zinc from the Slightly Deformed State to the Polygonized State.** (In French). P. A. JACQUET. *Comptes Rendus*, 237, 1248-1250, 1332-1334 (1953) Nov. 16, Nov. 23.

Thin sheet specimens of 65/35 α -brass, heat treated to give grain sizes from 0.04 to 0.08 mm., were strained under tensional loads up to 4.5 kg./mm.² this being just sufficient to produce a measurable extension. The surfaces were electropolished and then anodically attacked in sodium hyposulfite solution to give preferential attack at the grain boundaries and slip bands. The attack on the slip bands was not continuous but resolvable into a series of fine depressions with the appearance of angular etch pits spaced at intervals of about 0.5 micron along the glide band. On annealing at temperatures of 200-500 C and re-etching the attack became more dispersed, the pits disappeared and were replaced by a net-

work of etched lines. Annealing at 600 C caused the formation of a network delineating a domain structure within the grains.—BNF. 7963

3.6 Electrochemical Effects

3.6.8, 3.2.3

Contribution to the Theory of Chemical Polarization During the Solution and Separation of Metals, and Addition to the Theory of Overvoltage. (In German.) WILLI MACHU. *Werkstoffe und Korrosion*, 5, No. 3, 87-92 (1954) March.

Formation of surface layers has considerable influence on chemical polarization which occurs during the solution, separation, polishing and passivation of metals. Polarization is observed on the cathode as well as on the anode. The surface layers exercise a restraining effect on the adjustment of the equilibrium of association. Surface layers which cause a change in polarization or overvoltage are different from macroscopic layers such as oxides, rust, salts and they also differ from microscopic layers. They can be considered as "reversible" surface layers, because they are created by a slowing down in the speed of the diffusion of the ions necessary for the dissolving of the metal in relation to the more rapid formation of layers on the surface of the metal. Their formation continues at a very high reproductive rate, even though the top layers are removed and they form an indication of the behavior of the metal in solutions after it has been subjected to suitable preliminary treatment. Besides the influence of surface layers other factors are responsible for chemical polarization, polishing, etc., which are too complex to be explained in brief terms.—ALL. 7949

3.6.9, 8.9.3, 5.2.1

Extraneous Currents Noted on Large Transmission Pipe Line System. N. J. ALLISON AND W. E. HUDDLESTON. *Corrosion*, 8, No. 1, 1 (1952) Jan. 7926

3.7 Metallurgical Effects

3.7.2, 3.6.5

On the Solution Potential of Iron-Chromium Alloys After Abrasion in an Inert Atmosphere. (In French.) HENRY HATWELL. *Compt. rend.*, 236, No. 19, 1881-1883 (1953) May 11.

Chaudron, Lacombe and Youssov have shown [*ibid.*, 229, 201 (1949)] by electropolishing aluminum in an inert atmosphere that, with the elimination of the oxide film (which can be almost complete), a value of the potential very close to the theoretical value is obtained. Hatwell used a specially constructed apparatus to determine the potential of various metals after abrasion in pure argon. Results are given. In all cases the values in argon tend towards the potential calculated from thermodynamic data. The results of experiments on electropolished specimens of iron-chromium showed that up to 12 atomic percent chromium the potential is virtually the same as that for iron, but that at higher chromium contents the alloy had a potential positive in relation to that of the calomel electrode. When the specimens were abraded in argon, however, no discontinuity occurred in the potential curve up to 25 atomic percent chromium, so that the alloys, when deprived of their surface skins,

showed throughout a potential approximately equal to that of iron.—MA. 8019

3.7.2, 6.2.5

The Electrochemical Behaviour of Iron-Chromium Alloys in Potassium Nitrate and Dilute Nitric Acid. T. HEUMANN AND W. ROSENER. *Z. Elektrochem.*, 57, No. 1, 17-22 (1953).

Polarization curves of iron-chromium alloys (up to 30 percent chromium) exhibit unusual behavior in anodic passive region. In dilute potassium nitrate, alloys containing up to 17 percent chromium behaved similarly to pure iron, no metal being dissolved. Higher chromium alloys are dissolved, similar to behavior of pure chromium; oxygen evolution is noted only in former case. In dilute nitric at low current densities, alloys exhibit typical chromium behavior, but at higher densities, behavior is characteristic for pure passivated iron. Data for 18/8 stainless show that this behaves similarly to iron-chromium alloy containing 25 percent chromium. Distinction must be made between the passive layers on iron and chromium.—INCO. 8023

3.7.3, 7.2, 6.2.4

Quench Cracks in Wrought Steel Tubes. C. WELLS. *Carnegie Inst. Tech. Metal Progress*, 65, No. 5, 113-121 (1954) May.

Investigation of quench cracks in wrought steel tubes. Compositions were between the following limits: 0.25-0.5 percent carbon, 0.6-0.8 percent manganese, 0.6-2.2 percent chromium, 0.7-2.4 percent nickel, 0.25-0.5 percent molybdenum, and 0.0-0.1 percent vanadium. Typical data show that cracking susceptibility is a heat characteristic, the occurrence of cracking is epidemic in nature and the tendency towards cracking varies among tubes from a single heat. Effect of pouring temperature, ingot size and forging reduction, section size, surface defects, primary ingot structure, bore defects, gas content, carbon content and alloying elements on cracking susceptibility is discussed. Remedies for quench cracking include prebore quenching of tubes, a change from basic open hearth to basic electric steel and rough machining before heat treatment. Tables and graphs.—INCO. 7947

5. PREVENTIVE MEASURES

5.3 Metallic Coatings

5.3.2

Adhesion of Zinc Coatings to an Iron Base. (In Russian). K. M. GORBUNOVA AND P. D. DANKOV. *J. Phys. Chem., USSR* (Zhur. Fiz. Khim.), 27, No. 11, 1725-1730 (1953) Nov.

Discusses results obtained by Gorbunova and A. I. Zhukova (published in Russia, 1939-40) for the work needed to peel off zinc electrodeposits from iron surfaces which had received various treatments prior to plating. The values are greater than expected; this is explained in terms of deformation of layers of zinc atoms.—BNF. 7932

5.3.2, 5.9.4, 4.6.10

The Effect of Chromate Films on the Corrosion Resistance of Hot Dip Galvanize in Brine. F. J. BUBSEY. *Metal Progress*, 65, No. 5, 122-124 (1954) May.

Whenever the problem of surface protection of iron or steel arises, preference is given to a zinc coating over other finishes. Period of protection can be ex-

tended for certain environments by treating the zinc coating with chromium salts so as to retard the over-all corrosion. Another benefit gained from chromate treatments is that the formation of products of zinc corrosion is prevented or minimized. Corrosion tests of the chromate film were made at room temperature and by total immersion of the specimens in brine. Results are discussed. Tables and graphs.—INCO. 8013

5.3.2, 6.2.3

High-Temperature Corrosion-Resistance of Aluminum-Covered Low-Carbon Steel in Relation to the Method of Covering. (In Polish). TADEUSZ DRAZKIEWICZ AND STANISLAW GEBALSKI. *Prace Inst. Mech.*, 3, No. 9, 16-41 (1953).

Results of high-temperature corrosion tests in an oxidizing atmosphere, followed by metallographic analysis of steel specimens covered with aluminum by three different methods, led to the following conclusions: 1) Of the protective coatings used, the best results were obtained with water glass. 2) At 400C all three methods (cementation with aluminum powders, immersion in liquid aluminum and spraying with aluminum) produced surface layers of equal corrosion-resistance. 3) At 700 and 950C, good resistance was shown by specimens coated by immersion and spraying methods. The powder cementation method led to much inferior results. The tests lasted 100 hours in each case. The process of diffusion at the aluminum/iron boundary was studied in relation to time and temperature of the test.—MA. 7935

5.3.2, 6.4.2

Breaks in Aluminium Coating on the Alloy AU.G (Duralumin) Compatible with Protection Against Corrosion. (In French). G. GAUTHIER. *Rev. Met.*, 50, No. 8, 551-557 (1953).

Gauthier investigated the extent to which a scratch in the protective aluminum coating on Duralumin-type alloys could be considered as a discontinuity in the protection afforded by the coating. It is clear that in the case of both a scratch and a more considerable gap the coating will protect the base metal for a certain distance. The only measurements so far published are those of Brenner and Roth (*Z. Metallkunde*, 29, 334), but these are not complete. Gauthier prepared specimens of AU.G clad with aluminum and having grooves in the direction of rolling 2 mm deep and 1, 5, 15 and 30 mm wide cut in them. These, together with both ungrooved and unclad specimens, were: 1) exposed uninterruptedly to 3% sodium chloride spray for 13-28 weeks, 2) exposed to the atmosphere on a factory roof, 3) alternately immersed in artificial sea-water, and 4) immersed in the Mediterranean. The degree of corrosion was determined by the appearance of the specimens and by tensile tests. The distance up to which the protection of the coating extends is of the order of 1 cm. A groove extending down even to the base metal is no more a cause of corrosion than a superficial scratch.—MA. 7927

5.3.2, 7.5.2

Improvement of the Corrosion Resistance of Tinplate by a Chemical Treatment. S. C. BRITTON AND R. M. ANGLES. *J. Applied Chem.*, 4, No. 7, 351-364 (1954) July.

Corrosion of tin by hot sodium hydroxide solutions is accelerated by small additions of sodium chromate but is retarded by larger additions. Tin-plate im-

mersed in solutions containing sufficient chromate remains bright and is resistant to other corrosion forms; pores in the coating rust less readily and surface is more resistant to staining by sulfur-containing material and oxidation. Trials of canning soup in treated tin-plate cans are described. Procedure is to immerse tin-plate in a solution containing 10 g. sodium hydroxide, 3 g. of sodium chromate and a small amount of wetting agent in 1 liter for three seconds at 90-95°. As a test, treated samples are immersed in a hot solution of 10 g. potassium monosulfide and 10 g. of sodium hydroxide in 1 liter for 30 seconds. Illustrations, 5 references.—INCO. 8009

5.3.4

Gas Plating Offers Versatility. *Steel*,

133, No. 16, 120-121, 124 (1953) October 19.

Metal carbonyl gas (also nitrosyls, hydrides, salts and metal organics) is circulated about the object to be plated. The workpiece is heated and the metal plates out as the gas contacts the hot surface. The process is not to be confused with vacuum deposition. The decomposition is controllable and can be made to produce metallic films such as those obtained by electroplating and other means. The final metal deposit is determined by 1) concentration of the metal compound in the carrier gas, 2) rate of flow of the plating atmosphere and 3) temperature of the objects to be plated. Basically, any metallic compound capable of being vaporized, having a decomposition temperature, may be used in the gas plating process.

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Where the process was used to provide extreme corrosion resistance inside piping and other equipment, samples plated on copper, iron and aluminum showed good mechanical adherence. The plate could not be peeled from the samples even after cutting. Microscopic examination in the vicinity of flow revealed no excessive attack by corrosion at plate substrate interface. As a supplement to electroplating, gas plating has several advantages: 1) irregular surfaces and inside of objects plated without special equipment; 2) process makes possible straight-line continuous plating of such materials as wire, screen, metal sheet, 3) process is faster.—ALL. 7895

5.3.4

Nickel Plating from the Sulfamate Bath. R. C. BARRETT. Barrett Chem. Prods. Co. Paper before Am. Electroplaters Soc., 41st. Ann. Conv., N. Y., July 13, 1954. *Plating*, 41, No. 9, 1027-1032; disc. 1033 (1954) Sept.

Historical development of the sulfamate nickel plating bath is discussed and basic composition of a commercial bath is presented. Attention is focused upon the stress-free character of nickel deposits obtained from the sulfamate bath along with data upon other physical properties. Specialized applications concerned with heavy metal deposition under controlled specifications are described and aspects of electroplating nickel in the electrolyzing, electroforming, phonograph record and aircraft industries are included. Control, maintenance, operating techniques and other data on the sulfamate nickel plating bath are described. Tables, graphs and 29 references.—INCO. 8007

5.3.4

Effect of Impurities and Purification of Electroplating Solutions. I. Nickel Solutions. 7). The Effects and Removal of Chromium. D. T. EWING, J. K. WERNER, A. A. BROUWER, C. J. OWEN AND W. O. DOW. *Plating*, 40, No. 12, 1391-1400; disc. 1400 (1953) Dec.; Cf. *ibid.*, 39, 1343 (1952).

A report of work carried out under Research Project No. 5 of the American Electroplaters' Society. The effects of hexavalent and trivalent chromium on the appearance, adhesion, ductility, salt-spray corrosion-resistance, hardness and throwing power of nickel deposits were studied. Watts-type baths of high and low pH, nickel-cobalt baths and organic baths were used. In general, moderate changes in appearance occurred; adhesion remained unchanged; ductility was lowered more by hexavalent chromium than by trivalent chromium; trivalent chromium decreased the corrosion resistance but hexavalent chromium had little effect. Electrolysis below 40 amp./ft.² was found unsatisfactory for the removal of either form of chromium, since hexavalent chromium was reduced at the anode. However, the concentration of chromium may be reduced to 5 mg./l. or less by precipitation with NiCO₃ at high pH, if the chromium is reduced first electrolytically, or chemically with nickel metal at low pH. Hexavalent chromium in sufficient quantity will prevent the electro-deposition of nickel.—MA. 7923

5.3.4

The Analysis of Electroplating Solutions for Major Constituents. EARL J. SERFASS. *Plating*, 40, 1385-1389; disc. 1389-1390 (1953) Dec.

Analyses available methods for determination of macroconstituents in chro-

mium, silver, nickel, and brass plating baths. Tables, diagrams.—MR. 7884

5.3.4

The Use of Aluminium in Metal Spraying. (In German). HARRIBALD SPRENGER. *Z. Metallkunde*, 44, No. 5, 219-223 (1953).

Pure aluminum is used in both wire- and powder-gun metal-spraying processes, primarily for the corrosion and oxidation protection of steel. Sand-blasting of the base metal is essential to provide a good key. The thickness of the aluminum layer varies between 0.1 and 0.3 mm; thinner coatings do not offer adequate protection, thicker ones tend to crack owing to shrinkage. The porous sprayed deposit forms an excellent base for corrosion-resistant paints. Protection by aluminum spraying is more expensive than other methods, but lasts longer, so that it is specially suitable for inaccessible structures. For oxidation-resistance, a 0.3-mm layer is covered with water glass, bitumen, or borax and diffusion-annealed for 3-4 hr. between 700 and 1000, mostly at 800-850°C. A diffusion layer forms at the interface and ensures good adhesion of the aluminum layer, which, on oxidation, forms a protective scale. This has been found beneficial even on nickel-containing heat-resisting steels, because it is resistant to sulfur-bearing atmospheres.—MA. 7877

5.3.4

Bronze Plating Solves Design and Corrosion Problems. W. H. SAFRANEK, W. J. NEILL, AND D. E. SEELBACH. *Steel*, 133, 102-104, 106, 109 (1953) Dec. 21.

Account of "Lustralite," a new process for bronze plating developed by Battelle. Bath contains soluble stannous pyrophosphate complex, copper cyanide complex and addition agents. Different deposits obtained by varying metal ratio, e.g., "Lustralite" 10, 20 and 45, producing deposits containing approximately 10%, 20% and 45% tin respectively. Applications: bearings, salvage of mis-machined parts, stop-off in nitriding, electroforming and decorative uses.—BNF. 7894

5.3.4, 1.6

Electrodeposition of Titanium. ALBERT W. SCHLECHTEN, MARTIN E. STRAUMANIS, AND C. BURROUGHS GILL. Missouri Univ. School of Mines and Metallurgy. Sept., 1953, 56 pp. (WADC-TR-53-162 (pt. 1); AD-23333).

The high resistance of titanium to corrosion, particularly by sea water or nitric acid, makes it very desirable to plate other metals with a protective coating of titanium. Many attempts by many workers have been made to electrodeposit titanium either to form a coating or as a means of producing the metal, but little success has been reported. This report describes a large number of experiments using aqueous and fused salt baths. It is doubtful if any true electrodeposits of titanium were obtained, but a procedure is described which will yield a thin but coherent and corrosion resistant titanium coating. Extensive data are also reported on the hydrogen overvoltage on titanium in aqueous electrolytes. (auth).—NSA. 7972

5.3.4, 1.6, 8.8.3

Electrodeposition Research. Proceedings of the National Bureau of Standards Semicentennial Symposium on Electrodeposition Research, December 4-6, 1951. National Bureau of Standards Circular

No. 529, 1953, 129 pp. U. S. Government Printing Office, Washington, D. C.

Contents: G. E. Gardam, Research on Electrodeposition in Great Britain; J. Salauze, Electroplating Research in France; P. Baeyens, Electroplating Research in Germany, Belgium, and Holland; William Blum, Electrodeposition Research at the National Bureau of Standards; C. L. Faust, Electrodeposition Research at Battelle Memorial Institute; A. E. Tripler, Jr., An Investigation of Electrodeposited Alloys and Pure Metals as Substitutes for Zinc and Cadmium for Protective Finishes for Steel Parts of Aircraft; L. D. McGraw, The Mechanism of Hydrogen Entry into Metals; W. H. Safranek, Electroforming Aluminum; J. E. Stareck, Electrodeposition Research at United Chromium, Incorporated (abstract); Oliver C. Ralston, Electrodeposition Research at the Bureau of Mines; William H. Colner, Electrodeposition Research in Progress at Armour Research Foundation; George W. Jernstedt, Electrodeposition Research of Westinghouse Electric Corporation; K. G. Compton and R. A. Ehrhardt, Brass Plating; R. A. Schaefer, Electroplating in the Sleeve-Bearing Industry; Walter R. Meyer, Research at Enthone, Inc., on Metal Finishing; M. R. Caldwell, L. B. Sperry, L. M. Morse and H. K. Delong, Corrosion-Resistance of Copper, Nickel, and Chromium-Plated Zinc, Aluminum, and Magnesium-Base Die-Castings; E. R. Bowerman, Plating Research at Sylvania Electric Products (abstract); Earl J. Serfass, Determination of Impurities in Electroplating Baths; D. T. Ewing, John K. Werner, and Arthur Brouwer, Effects of Impurities in Plating Solutions; Nathaniel Thon, Porosity in Perspective; Fielding Ogburn and Asaf Benderley, Correlation of Gas Permeability of Electrodeposits with Their Weathering Behaviour; Abner Brenner, Properties of Electrodeposited Nickel; Barnett F. Dodge, Charles A. Walker, and Walter Zabban, Disposal of Cyanide Wastes from Plating Operations; John Kronsbein, Current and Metal Distribution in Electrodeposition; H. B. Linford, A New Degreasing Evaluation Test: The Atomizer Test.—MA. 7941

5.3.4

Hot Dip Aluminizing. M. L. HUGHES AND D. P. MOSES. *Metallurgia*, 48, No. 287, 105-122 (1953) September.

Work carried out on hot dip aluminizing in the laboratories of The British Iron & Steel Research Association at Swansea, as a result of which the preliminary treatment of the strip prior to aluminizing has been greatly simplified. The effect on the product of variations in the process has been examined, including their influence on the properties of the steel base. Experimental batch aluminizing procedures and the operation of a pilot plant for continuous coating are described. Advantages of the hot dip aluminized coatings are: aluminum is more resistant to normal atmospheric corrosion than zinc, and superior under adverse conditions for zinc, for a given coating thickness, the weight is less than half that of zinc, the coating has useful heat resisting properties, a thinner coating is possible than in hot dip galvanizing (without using aluminum) and light cold rolling gives the product an excellent finish. Disadvantages are: the electrochemical protection is largely lost, owing to the inert, tenacious and continuous oxide film, due to this fact oc-

currence of pores is serious, and the alloy layer is very hard and brittle when pure aluminum is used in the bath, which fails badly under compression, but under tension is better than hot dipped zinc. Advantages of the process are: annealing and coating may be combined in one operation, less ash forms on a quiet bath, and dross formation has some favorable aspects in that, a. one pound of iron leads to 16-1/2 lb. dross in galvanizing, but only 2 1/2 lb. in aluminizing, b. the difference in density of the dross in hot dip aluminizing process should cause it to settle more readily. The relatively high temperature of operation leads to these disadvantages: greater cost, high tensile material is almost completely annealed, fabricated articles when dipped are subject to warping, the film on the surface of the bath may lead to unsatisfactory appearance of the product, and under certain conditions, the coating tends to de-wet, exposing the alloy layer and altering the coating thickness.—ALL. 7722

5.3.4

The Uniformity of Galvanized Coatings and the Expected Life of the Galvanized Article. N. B. RUTHERFORD. *Sheet Metal Inds.*, 30, No. 318, 891-893 (1953) October.

Withdrawal conditions were much more important than presence or absence of small aluminum content in producing uniform coatings. A modified practice made possible a reduction in zinc consumption without affecting expected life of galvanized ware. Diagrams, tables. 9 references.—BTR. 7808

5.3.4

High-Vacuum Metallizing of Metals and Plastics. *Ind. Finishing* (London), 5, No. 57, 546-550, 552-554, 556-558, 560-561 (1953).

A detailed article on the technique, costs and possibilities of the process. The metal coating is applied over a lacquer undercoat or sealer, the requirements of which are discussed. A protective lacquer topcoat is applied over the metal.—RPI. 7770

5.3.4, 5.3.2

Rhodium Plating and Its Modern Applications. E. H. LAISTER AND R. R. BENHAM. *Bull. Inst. Metal Finishing*, 3, No. 3, 181-203 (1953); *Trans. Inst. Metal Finishing*, 29 (1953).

Details are given of operating conditions and maintenance of sulfate baths from which rhodium can be directly deposited on copper, brass, bronze, nickel silver, speculum metal, gold, platinum, etc., but not on steel, zinc, aluminum, lead, tin, and most tin-lead alloys. Plating is easier on solders consisting of lead 95, silver 5 percent or lead 93 1/2, silver 1 1/2, tin 5 percent. The effects of bath impurities and the results of corrosion tests in various media are tabulated. The chemical, physical, and electrical properties of rhodium deposits are discussed, and typical applications are described. Thickness standards for various applications are suggested; these range from 0.000005 in. for light domestic use to 0.002 in. for heavy mechanical wear.—MA. 7757

5.3.4, 5.4.7

The "Colarit" Process (of Flame Spraying). JAN H. BOSCH. *Polytech. Tijdschr.* (A), 8, No. 5/6, 77A-81A (1953).

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origin is described and illustrated, by which metallic and other protective films can be applied hot to metal, stone, concrete, or wooden surfaces. Large pieces, too unwieldy for immersion, can be tinned in this way and a thicker protective film is attained than with other methods.—MA. 7644

5.3.4, 6.2.2, 3.2.2

Galvanizing Embrittlement of Blackheart Malleable Iron. G. N. J. GILBERT. *J. Research and Development of Brit. Cast Iron Res. Assoc.*, 5, No. 3, 124-131 (1953) Dec.

Previous work on the effect of phosphorus on galvanizing embrittlement has been confirmed. With a phosphorus content of 0.07% and a silicon content of 1% there is little danger of embrittlement at normal temperatures due to galvanizing. When used under low temperature conditions, some galvanizing embrittlement might be detected, since the transition temperature is raised by quenching low phosphorus material from 450°C. It is recommended that when blackheart malleable castings are to be galvanized, the phosphorus content should be kept as low as possible below 0.1% and preferably below 0.07%. If higher phosphorus contents cannot be avoided, all castings should be quenched from 650°C before galvanizing.—ZDA. 7715

5.6 Packaging

5.6.3, 1.6, 5.5.3, 5.4.5

Temporary Prevention of Corrosion on Metal Surfaces During Transportation and Storage. British Standard 1133: Section 6: 1953, 98 pp. British Standards Institution, London.

This publication, in two parts, is a revision of the wartime booklet 'Corrosion Prevention.' The first part deals with available methods, the second sets up performance standards, with an appendix containing testing procedures. The majority of the tests require elaborate control and equipment which even the larger firms will consider inaccessible. Such tests are valuable, however, not so much for routine control as in the development of new processes.

The section on methods of corrosion prevention is both incomplete and sometimes seriously misleading. Particularly, it is strange to find that with the exception of solutions for the pickling of steels, no details of the materials are given and in each case the reader is referred to proprietary processes. This is excusable, in our opinion, only where there is no standard process available or where the proprietary process is in some way unique. In the section on pickling and descaling, only methods for steels are given. The concentration range of hydrochloric acid pickling is given as 1 to 50% of the concentrated acid; it is suggested that 10-100% would have better represented good commercial practice. The publication also says that often the heat of the action is sufficient to keep the bath at 30-40°C at which rapid pickling takes place. While this statement is undisputed, it is wrong to leave the reader with the quite erroneous impression that 30-40°C is the temperature to be aimed at in hydrochloric acid pickling. This is essentially a room-temperature process. Any heating that takes place is incidental and can be harmful. In the section on drying, only the use of compressed air,

drying ovens and water displacing fluids is described. There is no mention of centrifugal dryers or of the old, extremely popular and incidentally highly efficient method of sawdust drying. Similarly, not nearly enough emphasis is given to adequate rinsing before drying.

The corrosion preventatives themselves are divided into eight types including hard and soft films applied by cold dipping, spraying or hot dipping, soft grease films applied by smearing or slushing, oil films, strippable hot dip coatings, and vapor phase inhibitors. In each case a general description is followed by properties of the films or materials, the method of application and some notes on their use and type of primary wrapping that is required. Again, however, no details of composition are given and the user is left to find his own source of supply.

No attempt has been made to relate these processes to the actual corrosion problems in transportation and storage. For instance, the subject of storage conditions for in process and finished components is entirely neglected though it is of equal importance to the use of preventives.—EL. 7724

5.7 Treatment of Medium

5.7.4, 8.9.5

Dehumidifier System for Cargo Protection. *Marine Eng.*, 58, 77 (1953) Sept.

A new dehumidifier system for cargo protection has been developed by Bethlehem Steel Company, Shipbuilding Division, in conjunction with Surface Combustion Corporation of Toledo, Ohio. Disclosure of the new system followed conclusion of successful tests of the new method on the *Yorkmar*, of the Calmar Steamship Corporation, on a recent voyage from Philadelphia to the West Coast, via the Panama Canal. Termed the "Bethlehem pressure system of cargo hold dehumidification," it dehumidifies the air entering cargo holds and prevents "sweating" of the bulkheads and dripping of this precipitation on to the cargo. Condensation occurs under certain conditions when the temperature of the moist humid air inside the cargo hold is higher than the temperature of the sea water through which the vessel is passing. Sweating resulting from this condition often damages or impairs corrodable or moisture-sensitive cargo. However, if the air is sufficiently dehumidified so that the moisture therein does not precipitate out of the air, condensation is eliminated and atmospheric corrosion becomes negligible. On the *Yorkmar*, moisture is removed from the air by a 7,000-c.f.m. Kathabar dehumidifier manufactured by the Surface Combustion Corporation. Test of the system began early in April when the *Yorkmar* was loaded with 11,000 tons of finished steel in the form of pipe, sheets, strip, cold finished bar stock, structural shapes, rails and wire, much of which was rain drenched. With the system in constant operation, the vessel made the voyage to Long Beach, California. The vessel's cargo was inspected there by a delegation of marine surveyors and Bethlehem Pacific Coast Steel Corporation. The delegation found the cargo almost completely free of corrosion from any source. The new system has the advantages of low initial cost, simple operation, minimum maintenance expenses and avoids the necessity for expensive instrumen-

tation and trained air-conditioning operating personnel on board.—TIME. 7829

5.9 Surface Treatment

5.9.1, 5.3.4

Technical Developments (in Metal Finishing) 1953. N. HALL. *Metal Finishing*, 52, No. 1, 52-61 (1954) January.

A review of technical developments in metal finishing under the headings: cleaning, pickling, polishing, plating and anodizing of aluminum, plating on difficult metals, metallic coatings, vacuum and vapor metallizing, corrosion preventive conversion films, testing and control, and treatment and disposal of wastes. 311 references.—BNF. 7686

5.9.1, 6.4.2

Protective Anodizing of Highly-Reflective Aluminium. SAKAE TAJIMA, YASUYUKI KIMURA, AND TOSHIRO FUKUSHIMA. *Metal Finishing*, 51, No. 9, 69-73 (1953) Sept.

The reflectivity and corrosion- and abrasion-resistance of polished and anodized commercially pure aluminum were studied. Reflectivities of 75-90% were obtained by the chemical polishing of 99.6 and 99.19% aluminum and by the electro-polishing of 99.6% aluminum. The reflectivity of 99.19% aluminum was between 68.5 and 80.5%. A final light buffing was used to secure more specular reflection. The chemically polished 99.6% aluminum was anodized in a number of electrolytes. At 25C with a current density of 1.0 amp/dm², transparent films were obtained by a 5-minute treatment in oxalic acid above 5% by weight; sulfuric acid above 2% by volume; sodium bisulfite above 20% by weight. Sulfamic and phosphoric acids gave unsatisfactory films. Transparent films were also formed in chromic acid baths at 0.5 amp/dm². The more transparent films were formed generally in the more concentrated baths, but corrosion- and abrasion-resistance were somewhat lower.—MA. 7929

5.9.2

Descaling by Reduction of Scale with Sodium Hydride. A. V. SMIRNOV, S. A. SEMENKOVICH, AND F. A. BOGACHEV. *VESTNIK MASHINOSTROENIYA (Factory Laboratory, USSR)*, 33, No. 3, 37-39 (1953) March.

Merits of reduction of scale with the use of sodium hydride vs. acid pickling or dipping. Thermodynamic calculations underlying this process. Experiments conducted by authors. Setup used. Procedure. Effectiveness of scale removal determined by weighing the specimens before and after the treatment, and compared with results obtained with three other descaling processes. Economics of process, its special advantages for the descaling of high alloy steels. Translation available: Henry Bratcher, P. O. Box 157, Altadena, California. 7898

5.9.2

Evaluation of Surfactants. Radiometric Evaluation of the Efficiencies of Various Surfactants in Displacing Water From Steel. J. E. SMALLWOOD AND STANLEY L. EISLER. *Soap Sanit Chemicals*, 29, 48-51, 101, 102 (1953) Aug.

Results are reported for 89 materials, using Na₂S₂O₈ as soiling agent. Data may help in evaluating water displacement powers of rust preventives. Tables 3 references.—MR. 7882

5.9.2, 1.6, 7.1

Improvement of Jet Engine Descaling Procedure. G. M. BRYAN. Northrop Aircraft, Inc., August, 1952, 55 pp. Contract AF33(038)-23310; (WADC-TR-52-100).

X-ray-diffraction analysis of the Inconel scale on combustion tube inner liners revealed that it is composed of nickel oxide, the major component and lesser amounts of chromium oxide and iron oxide. Metallographic examination demonstrated that heavy scale is associated with precipitation, possibly carbides at the grain boundaries, a fact which can explain intergranular corrosion of scaled Inconel in acid solutions. Inconel scale could not be taken off in neutral or alkaline solvents, but several acid solutions were found which remove most of the scale without seriously attacking the base metal. Oxidizing pretreatments, particularly with the alkaline permanganate solution in current use by the Air Force, were shown to promote efficient acid pickling. Physical tests of Inconel specimens descaled with the nitric acid-ferrous chloride solution revealed that high-temperature pickling (160F) caused a severe loss in tensile strength, whereas room temperature pickling caused no appreciable loss in tensile strength. A full scale test of the nitric acid-ferrous chloride solution was performed and satisfactory results were achieved. (auth).—NSA. 7925

5.9.2, 8.7.2

A Simple Reproducible Method for Determining Metal-Cleaning Efficiency. ARNOLD MILLER AND EDWARD A. HEDMAN. A.S.T.M. Bull., No. 194, 51-52 (1953).

A test is described which evaluates the perspiration-removal efficiency, free-rinsing qualities and possible corrosion-preventive characteristics of metal cleaners for fine instruments. Specimens of leaded brass were prepared by degreasing in hot alkali, pickling in acid, abrading, and finally oiling. Specimens with and without fingerprints were exposed at 65 C and 100% relative humidity for 12 hours after various cleaners and cleaning methods had been applied. Where the cleaner had poor fingerprint-removing properties, corrosion at the fingerprint occurred during test.—MA. 7916

5.9.2

Theory and Practice of Chemical Polishing. Part I: Chemical Processes for Copper-Base Alloys. Part II. Processes for Light Alloys, Iron Group and Other Metals. R. PINNER. *Electroplating*, 6, Nos. 10 & 11, 360-367, 401-410 (1953).

Part I. The theory of chemical polishing is briefly discussed. Bright dipping of copper and copper alloys and the Battelle chemical polishing process are reviewed. Results obtained by a new process are described. Talysurf and results on dissolution rates are given.

Part II. Processes for aluminum and its alloys, iron and steel, stainless steel, zinc, cadmium, silver and lead, and rare metals are reviewed.—EL. 7804

5.9.2, 6.2.5, 5.9.3

Cleaning Stainless Steel Work. Part II. (Concluded). E. M. RAINS. *Sheet Metal Worker*, 44, 80-81, 141 (1953) Sept.

Describes cleaning of outdoor installations, place of chemical cleaners in difficult jobs, how to remove hard water-detergent film, eliminating stencils and grease pencil marks, and methods for cleaning industrial equipment. Photographs.—BTR. 7794

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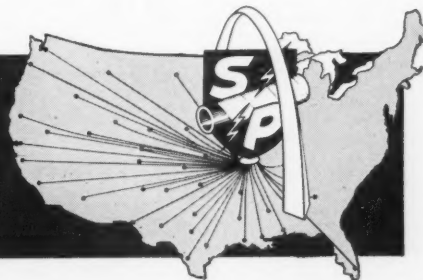


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5.9.3

A Further Study on the Effect of Abrasive Metal Polishing on the Character of Nickel Plate. W. L. PINNER. *Plating*, 40, No. 10, 1115-1118, 1123-1125; disc., 1125 (1953) October.

The result of various abrasive polishing procedures on steel surfaces is described and illustrated by photomicrographs. The effect of steel slivers and fragmented metal particles on the smoothness, buffability, and corrosion-resistance of plated coatings is discussed. Anodic acid etching was found to be more effective than a final polishing operation with a lubricant for removing these fragments, and details are given of a further stage after etching for removal of any resultant carbon smut. 2 references.—MA. 7803

5.9.3

Powder Processes Solve Tough Metal Removal Problems. Parts I, II, III. R. S. BARCOCK. Linde Air Products Co. *Iron Age*, 174; Nos. 4, 6 & 7; 105-108, 109-112, 122-124 (1954) July 22, August 5, August 12.

First developed for stainless steels, powder processes are now used on cast iron, high-temperature alloy steels, nickel and nickel alloys, 70-30 copper-nickel, copper and copper alloys, aluminum, reinforced concrete and firebrick. Processes include cutting, scarfing, gouging, lancing and washing. Iron powder fed into an oxyacetylene flame oxidizes rapidly and greatly increases flame temperature. Tough refractory oxides are easily melted, permitting the oxygen to attack the base metal. Powder

cutting has no effect on stabilized stainless steels such as titanium-bearing Type 321 and niobium-bearing Type 347. Non-stabilized types (301, 302, 308, 309, 310, 316 and 317) are affected by heat and are subject to subsequent corrosion. Assemblies that have been powder cut can be restored to full corrosion resistance by proper annealing. Tables give recommended powder blends, conditions for manual powder cutting of 18-8 and typical conditions for powder cutting nonferrous materials, including Monel, nickel, Inconel and Hastelloy C and B. Illustrations.—INCO 7993

5.9.4

Solubility Factor in Metal Phosphate Pre-Treatments. MAX KRONSTEIN, PHILIP HIXON AND JACK GRANOWITZ. *Paint and Varnish Production*, 43, 19-30 (1953) Dec.

Presents a study of metal-phosphate coatings on steel as a base for paint application. Graphs, tables, photographs, diagram. 4 references.—BTR. 7752

5.9.4

Structural Features of Oxide Coatings on Aluminum. F. KELLER, M. S. HUNTER AND D. L. ROBINSON. *J. Electrochem. Soc.*, 100, No. 9, 411-419 (1953) Sept.

Electronmicrographs show that anodic oxide coatings on aluminum consist of close-packed cells of oxide, predominantly hexagonal in shape, each of which contains a single pore. Pore size is a function of the electrolyte used and is independent of forming voltage. Wall thickness and barrier thickness are primarily a function of forming voltage and are affected to a minor degree by the electrolyte type. Dimensions of anodic coatings formed in sulfuric, oxalic, chromic and phosphoric acid are given with formulae for calculating cell size and pore volume.—EL. 7781

5.9.4

Metals in Phosphating Solutions: Determination by Ion Exchange. G. GABRIELSON. *Metal Finishing*, 51, No. 11, 63-64, 69 (1953) Nov.

Method of determination of the metal content in phosphating baths (manganese and zinc phosphate solutions) by means of a cation exchanger in the hydrogen form. The method is rapid and convenient for control of phosphating baths and concentrated phosphate solutions; an accuracy of 2-3% is claimed.—BNF. 7702

5.9.4

Radiometric Study of Supplementary Chromate Coatings for Zinc and Cadmium Plating. STANLEY L. EISLER, JONIE DOSS, AND MARY ANN HENDERSON. *Plating*, 41, No. 2, 147-154 (1954).

The investigation was undertaken to determine the effect of occluded SO_4^{2-} ions on the corrosion-resistance of chromate supplementary coatings for zinc and cadmium plating. Radio-active ^{65}Zn and ^{51}Cr were used to determine the amounts of SO_4^{2-} and chromium in the coatings from various dip solutions. By the use of a special technique it was possible to count the radiation emitted by each isotope in the presence of the other. It was found that the amount of SO_4^{2-} and chromium in the coat increases with the concentration of sulfuric acid in the solution, but not proportionately. The leaching of these two ions was also determined by exposure in running water and in a humidity cabinet. The loss of chromium was slow and not more



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| TP-1 | Report on Field Testing of 32 Alloys in the Flow Streams of Seven Condensate Wells (Pub. 50-3) NACE members, \$8; Non-members, \$10 per Copy. | T-4B-4 | Pipe-Type Cable Corrosion Protection Practices in the Utilities Industry. First Interim Report of Technical Unit Committee T-4B on Corrosion of Cable Sheaths. Publication 54-3. Per Copy \$5.50. |
| T-1A | Survey of Corrosion Control in California Pumping Wells. A Report of T-1A on Corrosion in Oil and Gas Well Equipment, Los Angeles Area. Pub. 54-7. Per copy, \$5.50. | TP-1D | Sour Oil Well Corrosion. Corrosion August, 1952, issue. NACE members, \$5.50; Non-members \$1 per copy. |
| T-1G | Sulfide Corrosion Cracking of Oil Production Equipment. A Report of Technical Unit Committee T-1G on Sulfide Stress Corrosion Cracking. Pub. 54-5. \$5.50 Per Copy. | TP-1G | Field Experience With Cracking of High Strength Steel in Sour Gas and Oil Wells. (Included in Symposium on Sulfide Stress Corrosion. (Pub. 52-3) \$1 per copy. 5 or more copies to one address, \$50 per copy. |
| T-1K | Proposed Standardized Laboratory Procedure for Screening Corrosion Inhibitors for Oil and Gas Wells. A Report of T-1K on Inhibitors for Oil and Gas Wells. Publication 55-2. Per Copy \$5.50. | TP-5A | Materials of Construction for Handling Sulfuric Acid. Corrosion, August, 1951, issue. NACE members, \$5.50; Non-members, \$1 per copy. |
| TP-2 | First Interim Report on Galvanic Anode Tests. (Pub. 50-2) NACE members, \$3; Non-members, \$5 per copy. | T-5B | High Temperature Corrosion Data—A compilation by NACE Technical Unit Committee T-5B on High Temperature Corrosion. Publication 55-6. Per Copy \$5.50. |
| T-2C | Some Observations of Cathodic Protection Potential Criteria in Localized Pitting. A Report of T-2C on Minimum Current Requirements for Cathodic Protection. Pub. 54-2. Per Copy \$5.50. | TP-5C | Stress Corrosion Cracking in Alkaline Solutions. (Pub. 51-3) Per Copy, \$5.50. |
| TP-3 | First Interim Report on Ground Anode Tests. (Pub. 50-1) NACE members, \$3; Non-members, \$5 per copy. | T-6A | Application Techniques, Physical Characteristics and Corrosion Resistance of Polyvinyl Chlor-Acetates. A Report of Unit Committee T-6A on Organic Coatings and Linings for Resistance to Chemical Corrosion. Publication 54-4. Per Copy, \$5.50. |
| T-3A | Some Corrosion Inhibitors—A Reference List. A Report of T-3A on Corrosion Inhibitors. Publication 55-3. Per Copy \$5.50. | TP-6G | First Interim Report on Recommended Practices for Surface Preparation of Steel. (Pub. 50-5) Per Copy, \$5.50. |
| T-4B-3 | Tests and Surveys for Lead Sheathed Cables in the Utilities Industry. Second Interim Report of Technical Unit Committee T-4B on Corrosion of Cable Sheaths. Publication 54-6. Per Copy \$5.50. | TP-6G | Second Interim Report on Surface Preparation of Steels for Organic and Other Coatings. (Pub. 53-1) Per copy, \$1; five or more copies to one address, per copy \$5.50. |
| | | TP-12 | Report on Electrical Grounding Practices. Per Copy \$5.50. |
| | | TP-19 | Corrosive Effects of Deicing Salts—A Progress Report by Technical Practices Committee 19. Corrosion, January, 1954, issue. NACE members \$5.50; Non-members \$1 per copy. |

than 10%. The SO_4^{2-} was lost more rapidly, continuing up to 70% in several weeks. The sulfuric acid content of the dip solution was not related to the corrosion-resistance of the coating, and NO_3^- -containing solutions were no better in this respect than SO_4^{2-} -containing solutions.—MA. 7873

5.9.4

The Density and Thickness of Anodic Oxide Coatings on Aluminium. A. PRATI. *Alluminio*, 22, 148-151 (1953).

The density at different thickness of anodic films were determined directly by means of the hydrostatic balance, as well as indirectly from the coating weight. Thickness was determined by the Abbé gauge. In normal conditions, the density was in accordance with the theoretical mean value of $d = 2.5$.—EL. 7800

5.9.4

Chromate Conversion Coatings. Amer. Soc. Testing Mat. Bull., No. 191, 41-42 (1953) July.

A summary of the information on chromate conversion coatings which is available at present, and of the problems which are yet to be solved. Acidified chromate type conversion coatings are widely used on zinc, cadmium and other metals. They provide corrosion protection and a good base for subsequent organic materials but little is known regarding the reaction which takes place in forming the coatings, their analysis, or the thickness of the film which is formed. 7664

5.9.4, 3.4.8, 6.4.2

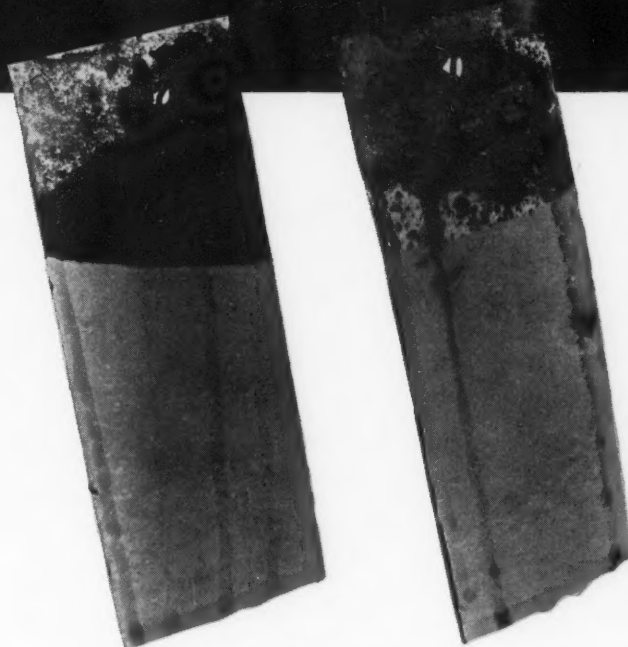
Effects of Aluminium Ion Dissolved in Electrolyte on Properties of Anodic Oxide Film on Aluminium—Effects on Properties of D.C. Anodic Oxide Film in Sulphuric Acid Process. TAKASHI KUNIMOTO, EIZO IKEDA, HIROSHI NISHIMURA AND HIROSHI TANI. *Light Metals* (Japan), No. 9, 63-68 (1953) November.

The effects of aluminum ion dissolved in sulfuric acid electrolyte were studied both in the production shop and in the laboratory. The increase of dissolved aluminum ion and the decrease of free sulfuric acid was determined by daily analysis of the electrolyte in the production shop. The effects of aluminum ion which was dissolved in 15% sulfuric acid by adding aluminum sulfide was studied on the properties of anodic oxide film. The results were: 1. The increase of dissolved aluminum ion and the decrease of free sulfuric acid are proportional to the anodized area. 2. The increase of dissolved aluminum ion is proportional to the decrease of electrical conductivity of the electrolyte. 3. The dissolved aluminum ion has no marked effect on the thickness of the film. 4. In connection with the corrosion resistance of the anodic oxide film, the small amount of dissolved aluminum ion has rather better effect, but it gradually lowers as the dissolved aluminum ion increases more than 0.2%. 5. The abrasion resistance of anodic oxide film rapidly lowers as the dissolved aluminum ion increases.—ALL. 7865

5.9.4

Study of Anode Potential During Electrolytic Polishing. P. BROUILLET AND I. EPELBOIN. *Comptes Rendus*, 238, No. 22, 2160-2162 (1954) May 31. (In French). Measurements of variations in anode potential after interrupting the current were made for several electropolishing systems. On aluminum, the potential

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These test panels of rusty steel were coated at the same film thickness and exposed side by side in a highly corrosive atmosphere (35% hydrochloric acid vapors) for the same length of time. Coatings on both panels were identical, with one exception: primer on left panel was new Rustbond #6, that on right was a popular competitive primer. In both cases, the topcoat was the same well known competitive brand.

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passes through a maximum, thought by the authors to indicate that there is no oxide film present during polishing but that one forms subsequently. The general conclusion drawn is that during electropolishing the anode potential is primarily determined by the contact potential of a layer of anions adsorbed on the metal surface.—BNF. 8012

5.9.4 Radiometric Study of Phosphate Coatings Formed on Steel in Pretreatment Baths. THOMAS F. BOYD, MICHAEL GALAN, AND LEONARD MARKOWITZ. *Corrosion*, 10, No. 9, 285-288 (1954) Sept.

An investigation has been made of the amount of phosphate coating formed on steel by various rust-inhibiting solutions. The treatments used were phosphoric acid, phosphoric acid with sodium dichromate and sodium nitrite with diammonium phosphate and with sodium phosphates. No correlation was found between the amount of phosphate coating formed and corrosion resistance. The nature of the coating appears to be the significant factor. The most corrosion resistant coatings were formed by diammonium phosphate-sodium nitrite and sodium phosphate-sodium nitrite treatments, the least by phosphoric acid alone. 8003

5.9.4 Conditions for Electrolytic Polishing of Metals and Alloys. S. H. BUSH. *Materials & Methods*, 39, No. 6, 137, 139, 141 (1954) June. (Materials Engineering File Facts No. 276).

A table giving details of conditions for electrolytic polishing of 21 metals, a variety of non-ferrous alloys, steels and cast iron with a bibliography of 57 references.—BNF. 8000

5.9.4, 6.4.4

Autoclave Treatment for the Production of Protective Coatings on Magnesium Alloys. (In German). G. SCHICHEL. *Metallurgie u. Giessereitech.*, 3, No. 7, 281-286 (1953).

Protective layers produced in the autoclave on magnesium alloys from different solutions were investigated. The grey layers produced by solutions on sodium hydroxide basis at 10 atm. are relatively thick and can be colored in light tones because of their absorption; the corrosion resistance is increased in fluoride solutions. Solutions based on sodium monosulfide produce at 10 atm. layers which can be dyed a deep black in the autoclave. At only 6-7 atm., thin hard bronze-colored layers are obtained. The layers produced by these three methods are superior in corrosion protection to all other methods. The bronze-colored layer offers best corrosion protection and is more economical to apply than the other way. The layers made at 10 atm. have a higher dielectric strength. Corrosion, impact and electrical tests and comparison with bichromate coatings. 7970

5.9.4, 4.3.2, 6.4.2

The Formation of Etching Figures in High-Purity Aluminum by Etching with Halogen Hydracids. A. POLITYCKI. *Metall.*, 8, No. 5/6, 173-176 (1954) March.

The formation of cubic etching figures in aluminum can be considered as the result of the influence of chlorine or bromine ions present in the etching bath. The cubic etching figures are changed into the equilibrium form of the metal—

which is the cubo-octahedron—when the action of the acid continues for a long time. If the decomposition is the result of rapid attack by iodine ions, cubo-octahedra are formed; fluorine ions produce no definite pattern. The formation of adsorption compounds seems to influence the solution process. If the anions play an important role in the decomposition they have to be in direct contact with the metal. With regard to space requirement and arrangement of the lattice units the following considerations may explain the behavior of the metal surface: fluorine ions are smaller than the atoms of the metal planes. They can adhere symmetrically to the most densely packed plane, i.e. to the octahedral plane and therefore to any surface of the metal. With chlorine and bromine ions this is only possible for the planes of a cube which are loosely packed. Iodine ions are too big; they cannot adhere symmetrically to any plane of the metal. Therefore only chlorine and bromine ions are expected to show preferred reaction on a special plane, which, in this case, is the cubic plane of the metal, because they are able to adhere closely to the metal atoms and produce adsorption bonds. This explains the formation of cubic etching figures as a consequence of spatial restrictions on the phase boundaries. It proves that the primary decomposition product is not an oxide but a halogenide.—ALL. 7875

5.9.4, 6.4.2

Anodic Behaviour of Aluminum and Its Alloys in Sulphuric Acid Electrolytes. RALPH B. MASON AND PHYLLIS E. FOWLE. *Metal Finishing*, 51, No. 10, 76 (1953) October.

This paper, presented at the 104th Meeting of the Electrochemical Society, at Wrightsville, N. C., September 13-16, 1953, deals with the main factors affecting the rate of solution of anodic oxide coatings on aluminum as they are being formed in sulphuric acid electrolytes. Conditions favoring high coating ratios or thick hard abrasion-resistant coating have been investigated. Low temperatures, high current densities, which permit a shorter time of immersion in the electrolyte, and the addition of substances such as oxalic acid to the electrolyte, favor the formation of such coatings. This has been mainly an investigation of the competition between the rate of formation and the rate of solution of the coatings.—ALL. 7817

5.9.4, 7.5.2, 5.3.2

Chemical Treatments for Protecting the Surface of Tinplate. E. S. HEDGES. *Metals: Corrosion-Industries*, 28, No. 332, 171-174 (1953).

Two small drawbacks met with in the use of tinplate food containers are referred to, viz. 1. the slight tarnishing occurring inside tins containing protein foods and 2. the appearance of small spots of rust on tinplate exposed to moist air. These and other defects can be eliminated either by a process of varnishing, or by coating the interior of the tin by anodic oxidation in dilute ammonium hydroxide or ammonium carbonate or a mixture of these two electrolytes, after removing grease and oxide by using the tin coating alternately as cathode and anode in the same electrolyte. Alternately, a film containing a hydrophilic colloid, e.g. Amidan, can be deposited by electrolysis in a solution of sodium aluminate. Cheaper

processes involve the immersion of the tins, after degreasing, for some minutes in a 10% chromic acid solution at 90°C, or by immersing the tins for some minutes in a hot alkaline solution containing both chromate and phosphate of sodium, whereby degreasing and oxidation are achieved together. The extremely thin coatings produced give complete protection against sulfur and a considerable degree of protection against moist air. This process of protection was found to be rather time-consuming. The time was reduced by using wetting agents, which reduced the operative time from 15 minutes to 30 seconds. Moreover, it was found that the tinplate could be treated in sheet form before making tins or boxes, without decreasing the degree of protection appreciably. This process, in a slightly modified form, is always used nowadays. Progress has been achieved in the U. S. A. in order to cope with the high rate of tinplate production, and in Britain it has been found possible to reduce the sodium hydroxide content of the bath used in the "Protecting" process to 1%, with 0.3% sodium dichromate and very little wetting agent, while the time has been reduced from 30 to 3 seconds. Adhesion of varnish has been improved.—MA. 7723

5.10 Other

5.10, 6.7.2

Infiltration Improves Properties of Metal Powder Parts. J. L. EVERHART. *Materials & Methods*, 39, No. 4, 88-90 (1954) April.

Infiltration of metal powder skeletons is rapidly growing as a method of producing strong metal powder parts. Porous titanium carbide compacts infiltrated with high temperature nickel or cobalt base alloys show excellent strength combined with notable ductility and impact resistance at temperatures up to resistance to oxidation up to this temperature. Table, graph and illustrations.—INCO. 7481

5.11 Design—Influence on Corrosion

5.11, 1.6

Metals Engineering: Design. O. J. HORGER, Ed. Book, 1953, 405 pp. McGraw-Hill Book Co., New York and London.

This book, produced under the aegis of the American Society of Mechanical Engineers, is part of the "A. S. M. E. Handbook"; three other volumes to be published later which will deal with Metals Properties, Engineering Tables, and Metals Engineering: Processes. With rare exceptions, the 48 sections deal in general terms with the essential properties which need to be evaluated by the design engineer in his selection of materials. After a short introduction on selection of material by H. W. Gillett, the other 47 sections are set out under mechanical properties of metals in design (31 sections), mechanical factors influencing corrosion (2 sections), metallurgical factors in design (7 sections, all dealing with non-destructive testing), processing considerations in design (2 sections), and design procedures (12 sections). Only three sections deal in detail with non-ferrous topics, i.e., aluminum, magnesium and metallic coatings.—BNF. 7757

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.3, 8.1.2

Recommendations on Methods of Protection Against Corrosion for Light Gauge Steel Used in Building. British Standards Institution, 2 Park Street, London, W.1. P. D. 420, Sept., 1953, 13pp.

Concerned with mild steel components not exceeding 10 S.W.G. (0.128 in.) in thickness, for general building construction. Six grades of protective schemes are described, comprising up to 3 coats of paint alone or over thick, thin or flash metallic coatings (zinc, aluminum, or terne), or a phosphate coating. General recommendations; protective schemes; paint systems; protective grades recommended for various exposure conditions; good design.—BNF. 7694

6.2.5

Observations on Three Non-Tarnishing Ferrous Alloys. A. A. KRISHNAN. *J. Sci. Ind. Research (India)*, A, 12, 451-453 (1953) September.

The pressing need for a relatively cheap tarnish-resistant alloy using materials entirely of Indian origin led to the development of three new aluminum manganese steels. Alloy #1 contains 8.47 aluminum, 26.21 manganese, 0.26 carbon, and 63.81% iron. Alloy #2 contains 13.66 aluminum, 23.54 manganese, 0.35 carbon, and 62.36% iron. Alloy #3 contains 9.59 aluminum, 21.51 manganese, 0.62 carbon, and 68.40% iron. Specific gravities of alloys #1, #2, and #3 are 6.8, 6.7, and 6.6 respectively. Alloys #1 and #3 can be forged easily around 950-1000°C. Their qualities are similar to those of 18-8 chromium nickel steel. Both have two-phase structures resembling S-80 type 16% chromium—2% nickel steel and have equal quantities of austenite and delta ferrite. Alloy #2, with a higher aluminum content, has a different structure in which needles of an iron-aluminum compound are present in a solid solution matrix. Cast alloys #1, #2, and #3 have a Vickers Pyramid hardness of 240, 316, and 328, respectively.

Whereas plain carbon steels quickly tarnish and rusted in the laboratory atmosphere, these new alloys retained their machined surfaces and showed no tarnish for over 6 months. On the basis of 400-hr. tests in tap-water, corrosion expressed as penetration in inches per yr. was 0.0001 for alloy #1 and 0 for #2 and #3. In 3% sodium chloride solution, penetration on the basis of 24 hr. tests was 0.0035 inches per year for alloy #1, 0.0050 in. for #2, and 0.0046 inches for #3. In 5% sulfuric acid and 5% nitric acid, corrosion penetration for alloy #1 was 390 inches and 5.0 inches per year, respectively. For alloys #2 and #3 corrosion in both reagents was high.

All three alloys are in the development stage and much more needs to be done before they can be recommended for industrial use.—PDA. 7831

6.2.5, 3.4.3, 4.6.1

Solubility of the Products of Corrosion of Stainless Steel in 600°F. Water. H. A. PRAY AND E. F. STEPHAN. Battelle Memorial Inst. U. S. Atomic Energy

Comm. Publ. (BMI-891), November 30, 1953, 12 pp.

The solubilities of the major elements from the products of corrosion of Type 347 stainless steel and analytical-grade iron in 600°F water were determined. Analyses were made of water samples taken both at room temperature and at 600°F. The tests were run in degassed water, water containing 200 ml/l of oxygen, water containing 200 ml/l of hydrogen and water adjusted to pH 10 with lithium hydroxide. The amounts of iron, nickel, and chromium found in the water samples at 600°F in all tests were less than 0.03 ppm. The room temperature samples were essentially the same. Because the solubilities were below the limit of analysis, it was not possible to determine the temperature coefficient of solubility. Under conditions involving a

temperature differential, and even if the temperature coefficient of solubility is high, the extremely low solubilities would require very large volumes of water in order to form an appreciable quantity of solid product from true solution. The presence of loosely adhering corrosion product on samples and autoclave indicates the possibility of transport of this solid material from the place of origin to another area by suspension, rather than in true solution, especially in a flowing system.—NSA. 7859

6.2.5, 3.6.2, 3.6.6

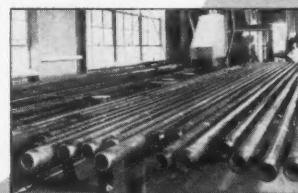
Contact Corrosion of Stainless Steels in Water at Temperatures up to 600°F. H. A. PRAY AND W. E. BERRY. Battelle Memorial Inst. U. S. Atomic Energy Comm. Publ. (BMI-886), November 24,

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1953, 24 pp. Declassified March 1, 1954.

The seizing of stainless steel couples by crevice corrosion in water at temperatures up to 600°F depends on several factors. Straight chromium steels (Types 410 and 430) seize more readily than chromium-nickel steels (Types 347 and 17-4). Seizing occurs more readily in crevices formed by journal-sleeve arrangements than in those formed by the mating surfaces of flat plates. Seizing occurs as a result of ferric oxide build-up at the periphery of the crevice area. Degassed water and water containing dissolved hydrogen or small amounts of lithium hydroxide retard the growth of ferric oxide. Increasing the amounts of dissolved oxygen in test water results in increasing amounts of ferric oxide being formed with subsequent seizing. Increasing the length of time on test also increases the possibility of seizing. Galvanic corrosion in water at 600°F is negligible on Types 347 and 410 stainless steels coupled to each other. (auth.)—NSA. 7857

6.2.5, 3.7.3

The Influence of Low-Temperature Treatment on the Mechanical Properties of Heat-Treated High-Speed Steel. V. I. MAKAROV. *Vestnik Mashinostroeniya*, 33, No. 12, 63-66 (1953) December; *Engr's Digest*, 15, No. 4, 164 (1954) Apr.

Samples of high-speed steel (0.74% carbon, 4.28% chromium, 18.73% tungsten, 0.26% vanadium, 0.48% molybdenum) were quenched at 1260°-1320° C and tempered at 50°-650° C. Influence of subsequent low-temperature treatment at -78°C on the mechanical properties of the samples was studied. These were determined by bending and torsion tests. Results show that bending strength goes up with tempering temperature from 200 kg/mm² without tempering to 300 kg/mm² at 550°C. Low-temperature treatment increases both values to 250 and 380 kg/mm² respectively. The influence of tempering temperature on torsion strength is equally pronounced, but not that of low-temperature treatment. In all cases, strength falls rapidly and ductility rises equally rapidly beyond a tempering tem-

perature of 550°C. Low-temperature treatment greatly increases the plasticity of the steel. Without cold treatment the steels show a brittle failure when tested in bending. After low-temperature treatment plastic deformation precedes failure. This property is expressed by the residual deflection. For steels tempered at 550°C, the residual deflection is increased 12 times by low-temperature treatment, while the ultimate strength increases in some cases by 30%. Also of interest is a fairly gradual variation of the shear modulus of the steel with tempering temperature for steels subjected to low-temperature treatment. The study included examination of chemical and crystallographic changes due to tempering and subsequent low-temperature treatment.—INCO. 7830

6.2.1, 6.3.1, 6.4.1, 3.8.4

History and Position of Research on Alloy Constitution. (In German). H. SPENGLER. *Metall*, 8; No. 1/2 & 3/4; 24-25, 107-115 (1954) Feb.

First part includes calculations of possible numbers of systems and those actually investigated. Thus, among the metals 3403 binary systems are said to be possible, 783 have been investigated; for ternary systems the numbers are 91,881 and 334. Second part lists binary systems which have been investigated, and groups them according to the type of constitutional diagram. Bibliography of all papers on binary systems from 1944 (the date of J. L. Haughton's bibliography) to autumn, 1953, also giving references to Metallurgical Abstracts.—BNF. 7966

6.2.2

G. E. Research Makes Crystals of Pure Iron. *Am. Metal Market*, 61, No. 51, 11 (1954) March 17.

Perfect crystal wires ("whiskers") of pure iron, about 0.001-inch thick and 1 inch long have been prepared by General Electric Co., USA, who claim that they are 100 times stronger than any known metallic crystal and do not rust.—BNF. 7990

6.2.5, 3.7.3, 5.12

The Fatigue Properties of Investment-Cast 0.2% Carbon, 18% Chromium, 2% Nickel Stainless Steel and Their Improvement by Nitriding and Shot-Peening. T. FITZGERALD AND J. E. NORTHWOOD. Brit. Ministry of Supply, Nat. Gas Turbine Establishment, Memo. No. M. 162, Oct., 1953, 25 pp.

Low fatigue properties were obtained with the 0.2% carbon, 18% chromium, 2% nickel stainless steel in the investment cast and heat treated condition. Attempts were made to improve its fatigue strength by processes which increase the endurance ratio, without any serious effect on tensile properties and ductility. Fatigue tests show that nitriding or shot-peening can be used to increase the fatigue strength of investment cast blades to a level on the par with that of the wrought material. Increases in fatigue strength of up to 40% above that of the "as-cast" surface condition were obtained by nitriding or peening the surfaces of buffed or electrolytically polished blades and test pieces. Nitriding lowers the corrosion resistance of 18/2 stainless when subjected to outdoor weathering tests, while shot-peening does not appreciably alter the corrosion resistance. Diagrams, tables, graphs, photomicrographs and 22 references.—INCO. 8039

6.2.5, 5.3.2

Protective Value of Chromium Plate on Type 410 Stainless Steel in Marine and Urban Atmospheres and in Tidewater. FRED M. REINHART AND DAVID B. BALLARD. U. S. National Bureau of Standards, Report No. 2406, April, 1953, 20 p.

An investigation was conducted to determine whether chromium-plated Type 410 stainless steel could be substituted for Type 316 stainless steel for some corrosive conditions in aircraft and whether chromium plating would increase the life of Type 410 stainless steel. In panel tests, the chromium plate (0.00041-inch) was discolored with reddish rust stains and the underlying steel rusted within 3 months of exposure in urban and marine atmospheres and was discolored with scattered rust stains within 6 months in tidewater. The chromium plate offered some protection to the Type 410 stainless steel in all three environments and the rust was tighter and more adherent than that on the unplated Type 410.

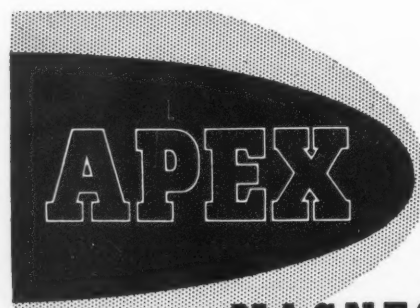
In general, however, chromium-plated Type 410 stainless steel would not be an acceptable substitute for Type 316 stainless steel in aircraft applications. This would be true, especially in cases where discoloration from rust stains would be objectionable. Where discoloration is not a factor, chromium-plated Type 410 stainless steel would probably be more satisfactory than the unplated type in atmospheric environments.—PDA. 7883

6.3 Non-Ferrous Metals and Alloys—Heavy


6.3.6, 4.3.3

Kinetics of the Dissolution of Copper in Aqueous Ammonia. J. HALPERN. *J. Electrochem. Soc.*, 100, No. 10, 421-428 (1953).

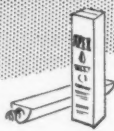
The reaction of copper with aqueous ammonia is given by: $\text{Cu} + \frac{1}{2}\text{O}_2 + 4\text{NH}_3$ (aq.) $\rightarrow \text{Cu}(\text{NH}_3)_4^{++} + 2\text{OH}^-$. At low oxygen concentrations the rate-de-



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421-D

termining factor is the transport of oxygen to the copper surface, but with excess oxygen the chemical reactions at the copper surface control the corrosion rate. Two reactions proceed simultaneously, and with independent rates, which are first-order with respect to the concentrations of ammonia and NH_4^+ . Mechanisms for these reactions are suggested. 9 references.—MA. 7729

6.3.8

The Effects of Some Constitutional Factors on the Creep and Fatigue Properties of Lead and Lead Alloys. L. M. T. HOPKIN AND C. J. THWAITES. *J. Inst. Metals*, **82**, 181-196 (1953) December.

An investigation of the creep and fatigue properties of extruded lead alloys based on a high purity lead. The effects of the amount and nature of the alloying addition, temperature and speed of extrusion, grain size and shape, occurrence of age hardening and precipitation of a second phase from solid solution, were examined. (Work done by Brit. Non-Ferrous Metals Res. Assoc.)—BNF. 7708

6.3.1, 1.6, 6.4.1

Modern Uses of Non-Ferrous Metals. C. H. MATHEWSON (Editor). Book (second edition), 1953, 530 pp. American Institute of Mining and Metallurgical Engrs., 29 West 39th Street, New York.

As compared with the first edition of 1935, most of the chapters have been revised by the original authors, some have new authors and necessarily a number of new metals are discussed. After an initial chapter on new industrial development and exploitation of metals and alloys, there are 25 chapters covering aluminum, arsenic, antimony, beryllium, bismuth, chromium, cobalt, copper, gold, lead, magnesium, manganese as a non-ferrous metal, molybdenum, nickel, platinum metals, silver, selenium and tellurium, silicon and germanium, tantalum and niobium, tin, titanium and zirconium, tungsten, uranium, vanadium, zinc and cadmium. There is no need to stress the value of a book of this kind written by individual specialists: the first edition was reprinted six times.—BNF. 7849

6.3.5, 3.2.3

Scaling of Niobium in Air. H. INOUE. U. S. Atomic Energy Commission Publ. (ORNL-1565), 1953, 16 pp.

The niobium used was high-purity strip containing small amounts of copper and titanium, and possibly tantalum; the oxygen content was 0.25%. Tests were carried out by a continuous-weighing method in dry air and in air with a partial water-vapor pressure of 18.6 mm. Hg at standard temperature and pressure; the temperature range was from 400° to 1200°C. At 400°C, in dry air, oxidation was sporadic and slow for 21 hr.; thereafter the rate was linear. The scale comprised a black oxide with an outer white matrix and was identified as the T form of Nb_2O_5 [Brauer, *Z. anorg. Chem.*, **248**, 1 (1941)]. The early course of the oxidation is due to a periodic rupture of a protective oxide, while the change to a linear rate is considered to result from the formation of the porous, white oxide. The effect of water at 400°C was found to be catalytic, increasing the linear rate by a factor of 90. At 600°C the oxidation in both moist and dry air was linearly related to time, the rate in moist being $\sim \frac{1}{2}$ that in dry air. In

both cases the oxidation product was the T form of Nb_2O_5 alone; only the white oxide was found at 600°C. The rates of oxidation were again linear at 800°C. The oxides were mixtures of T Nb_2O_5 and H Nb_2O_5 , and both black and white forms were present. At 1000°C the oxidation was linear with time, moisture having no effect on the rate; the oxidation product was the H Nb_2O_5 . No difference in behavior was observed at 1200°C. A plot of the log rate constant against $1/T$ gave a linear relationship with an inflection at 900°C, where the scale undergoes a modification of form. The activation energy was 13,400 cal./mole between 600° and 900°C, and 4350 cal./mole between 900°C and 1200°C.—MA. 7827

6.3.6, 1.6, 2.5, 6.5

A. S. T. M. Standards on Copper and Copper Alloys. Book, 1953, 540 pp. American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa.

This book brings together in convenient, up-to-date form all the A.S.T.M. Standards pertaining to copper and copper alloys, which were developed by Committee B-5 on Copper and Copper Alloys, Cast and Wrought, and other A.S.T.M. technical committees. It includes in their latest form 115 widely used A.S.T.M. standards, including 102 specifications; 9 test methods; 2 recommended practices—one for tension test specimens for copper-base alloys for sand castings, the other for designating significant places in specified limiting values; and 2 classifications—one for cast copper-base alloys, the other for copper. A high percentage of the material included in the earlier edition has been revised and four of the methods are new.

Standards cover copper, copper alloy, and copper-covered steel electrical conductors; non-ferrous metals; plate, sheet, strip, and rolled bar; rod, bar, and shapes; wire; pipe and tube; ingot; sand and die-castings; filler metal; and methods of test for copper and copper alloys.

A group of specifications cover non-ferrous metals such as slab zinc; pig lead; nickel; phosphor; silicon; electrolytic cathode copper, and others. Also included are test methods covering expansion; mercurous nitrate; resistivity; preparation of micrographs; tension; hardness; sampling; and grain-size evaluation.—MA. 7700

6.3.6, 2.2.2, 2.2.7

The Corrosion of Beryllium Copper Strip in Sea-Water and Marine Atmospheres. JOHN T. RICHARDS. Am. Soc. Testing Materials, Preprint No. 71, 1953, 18 pp.

Corrosion tests were carried out for periods up to 2 years on copper-1.9% beryllium-0.25% cobalt and copper-2.7% cobalt-0.5% beryllium alloys. Specimens were exposed to the marine atmosphere at Kure Beach at 80 ft. and 800 ft. from the sea. Tests were also carried out in sea-water at Harbor Island under the following conditions: 1. immersion in quiet sea-water (tidal flow), 2. immersion in sea-water flowing at ~ 3 ft./sec., 3. a rotating-disc test in sea-water giving velocities up to 28 ft./sec., 4. another rotating-disc test with specimens attached to the periphery of the disc, 5. jet-impingement tests of the aspirator type and the B.N.F.M.R.A.-type with

water speeds of 12 and 15 ft./sec. resp. Some measurements of electrode potentials and polarization curves were made. The results of exposure tests were expressed in terms of weight loss and decrease in strength and elongation. Phosphorus-deoxidized copper, arsenical Admiralty brass, 70:30 copper nickel (0.4% iron), and phosphor bronze (5% tin) were included in the tests as comparison materials. In all exposure tests the corrosion rates decreased with time. Where comparisons were made, copper-beryllium alloy was slightly better than copper-cobalt-beryllium alloy. Variations in temper and heat-treatment of the copper-beryllium alloy had a negligible effect on corrosion-resistance. 12 references.—MA. 7853

6.3.6, 3.4.8, 3.8.4

The Anodic Behavior of Copper in Neutral and Alkaline Chloride Solutions. H. LAL AND H. R. THIRSK. *J. Chem. Soc. (London)*, 1953, 2638-2644, Sept.

An account of work on the copper-water-chlorine system under neutral and alkaline conditions. This comprised a study of the anodic behavior of copper in neutral (0.1, 0.5, 1.0, 2.0, and 4.0 M-sodium chloride) and alkaline (N, 2N, 4N-sodium chloride + 1 g./l sodium hydroxide) solutions at 17° or 18°, 40°, and 60°C in the presence and absence of air. Changes in overpotential during constant-current polarization and after discontinuing the current were recorded. The results are not described in detail, but an overall picture is given of the behavior of the system under these conditions. Some observations are made on periodic phenomena occurring at high current density.—MA. 7765

6.3.6, 3.7.2

Corrosion Behavior of Special Cast Brass Alloys. (In German). E. PELZEL. *Metall*, **7**, No. 19/20, 767-771 (1953) October.

Aluminum brasses containing 0.31-1.54% iron, 0.31-1.26% manganese, and 0.30-1.50% nickel; silicon brasses with small additions of lead, arsenic, manganese, and nickel; and copper-zinc alloys of 50-60% copper content with additions of nickel and tin were tested for corrosion resistance in a solution of 3% sodium chloride plus 0.1% hydrogen peroxide. In addition the aluminum brasses were also tested in 10% hydrochloric acid and artificial sea water.

In general, small amounts of nickel and arsenic improved the corrosion resistance of aluminum and silicon brasses. Beta-type aluminum-iron-nickel and nickel-silicon brasses showed the best mechanical properties. In the heterogeneous (α & β) region, all alloys showed tendencies toward dezincification and occlusion of oxidation products.—PDA. 7801

6.3.6, 3.7.2

Gases in Phosphor-Bronzes. (In French). A. T. PAL. Congrès International de Fonderie, Paper CI-1, Sept. 1953, 7 pp. Obtainable from the Association Technique de Fonderie, 2 rue de Bassano, Paris 16e.

Taking the susceptibility to steam unsoundness as a criterion of deoxidation, it is shown that the addition of phosphorus to 10% tin-bronze performs no further deoxidation if the metal is melted under charcoal. This method of melting was not found to increase the absorption of hydrogen.—BNF. 7812

6.3.6, 4.3.5

The Corrosion of Copper by Elementary Fluorine. (Interim Statement of Results). P. E. BROWN, J. M. CRABTREE, AND J. F. DUNCAN. Atomic Energy Research Establishment, Harwell, Berks (England), (AERE-C/R-1241), April 27, 1953, 16 pp.

Data are presented on the effects of pressure, temperature, and heating during interruption of fluorination on the corrosion of copper by fluorine.—NSA. 7640

6.3.6, 8.8.1, 5.3.2

Lead in the Construction of Modern Chemical Installations. HANS H. HÖRGER. *Z. Metallkunde*, **44**, No. 4, 117-122 (1953).

The excellent corrosion-resistance and poor mechanical strength of lead make it extremely useful in the chemical industry and determine the manner of its employment. Separate components, which have to carry stress are made from alloys containing antimony or copper to improve strength and creep-resistance. Pure lead is used for the lining of vessels constructed in steel or copper sheet. Hot-dip and galvanic coatings are employed, but for applications involving little mechanical stress unbounded lead sheet linings are very successful, whereas in the presence of severe mechanical or thermal stresses preference is given to steel plate with a thick covering of lead which is weld-deposited on a thin tin intermediate coating.—MA. 7701

6.3.6

Fabrication of Copper and Copper Alloys: Some Common Faults. DAVID D. STEAD. *Australasian Engr.*, **1953**, 48-53, August.

Faults are discussed under the following headings: 1) manufacture of hot stampings or pressings, 2) corrosion failures, including stress-corrosion cracking, 3) fire-cracking, 4) annealing and heat-treatment difficulties, 5) hydrogen embrittlement or "gassing" of oxygen-bearing copper, 6) welding and brazing, 7) bending and similar forming operations, 8) spinning, drawing, and pressing, 9) machining, 10) electroplating and metal finishing, 11) troubles due to defective design, over-stressing during assembly, etc.—MA. 7891

6.3.6, 1.3

Copper and Copper Alloys: Survey of Technical Progress During 1953. E. VOCE. *Metallurgia*, **48**, No. 290, 289-293 (1953) Dec.

Copper production, foundry practice, fabrication techniques, finishing and plating, properties and applications, corrosion and protection, joining, powder metallurgy, physical metallurgy. Bibliography.—EL. 7988

6.3.6, 3.5.9, 3.2.3

High Temperature Oxidation of Copper-Aluminum Alloys. P. SPINEDI. *Metallurgia Italiana*, **45**, No. 12, 457-461 (1953) Dec.

Description of the results obtained from experiments carried out on various copper-aluminum alloys, with chemical compositions varying from 0.2 and about 20% of aluminum, utilizing a device by which it is possible to follow directly the variations in weight of a sample in function of the temperature.

The fact that the oxidizability of the alloys varies remarkably with the increase of the aluminum concentration is highlighted and the existence of a clear

interdependence between this oxidizability and the stable phase at the experimental temperature is observed.

On this basis some general conclusions are drawn in analogy to what has already been observed in preceding researches carried out at the Institute for Metallurgy in the University of Rome.—MI. 7888

6.3.11

The Chemical Properties of Gold (Alloys). (In German). ERNST RAUB AND ANNEMARIE ENGEL. *Z. Metallkunde*, **44**, No. 7, 298-301 (1953) July.

A report of a study of the resistance of gold solid-solution alloys of the binary type with silver, copper and nickel and of ternary and quaternary types with aluminum, copper, manganese, nickel, antimony, tin and zinc towards hydrogen sulfide containing atmospheres, M/5-Na₂S₂ solution, sulfur vapor (in vacuo) and a 3% sodium chloride + 0.1% hydrogen peroxide solution, all at 20°C and for 5, 15, 24 hours and 30 days respectively and an atmosphere of 80% relative humidity at 60°C. Plots of the increase in weight against total alloying components in wt.-%, show that small alloying additions cause an initial decrease in the corrosion-resistance of gold; alloying additions in the range 5-60 wt.-% lead to an almost constant rate of attack, but with further additions corrosion increases rapidly. In many cases, however, the composition range separating slow from rapid attack is so small that no true boundary can be defined. Of the binary alloys the resistance to attack by sulfur compounds increases in the order copper → silver → nickel; the reverse is true with sodium chloride-hydrogen peroxide solution. The rate of attack is similar, differing only in detail, irrespective of whether the material is in the cold-rolled or heat-treated condition. Lead-silver solid-solution alloys behave in a similar manner. Two references.—MA. 8001

6.3.11, 4.3.2

The Attack of HCl on Platinum. (In German). H. VON WARTENBERG. *Z. anorg. u. allgem. Chem.*, **273**, No. 1/2, 91-95 (1953) July.

Aqueous hydrogen chloride hardly attacks platinum perceptibly. The attack becomes very marked on addition of potassium chloride and cesium chloride (but not sodium chloride and lithium chloride). Similar effects occur with platinum, in molten cesium chloride or potassium chloride, with gaseous hydrogen chloride (no effect with lithium chloride or sodium chloride).—BNF. 8002

6.3.13, 6.3.20

Tantalum and Zirconium: Preparation and Properties. G. L. MILLER. *Ind. Chemist*, **29**, No. 345, 482-488 (1953) October.

General properties and production of tantalum and zirconium; sintering of tantalum powder and melting of zirconium; physical and mechanical properties; comparison of corrosion resistance of tantalum and zirconium with stainless steel; uses for chemical engineering.—BNF. 7838

6.3.14, 5.3.4

Tin and Its Alloys as Chemical Engineering Materials of Construction. R. J. NEKERVIS. *Ind. and Eng. Chem.*, **45**, No. 10, 2254-2260 (1953) Oct.

Part of the seventh annual Materials of Construction Review. Future prospects for tin, new tin-containing alloys

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6.3.15

How Stable Is Titanium in the Vital Operating Range. H. A. JOHNLE. *Iron Age*, 172, No. 17, 116-119 (1953) October 22.

The tensile properties of titanium-1.3% iron-2.3% chromium after ageing at 260°, 288° and 315°C for periods up to about 250 hr. are given. The material appears to age-harden owing to compound formation and decomposition of the metastable β -phase.—BNF. 7750

6.3.15, 2.3.4

Methods for Analysis of Titanium Alloys. *Anal. Chem.*, 25, No. 10, 1432-1449 (1953) Oct.

Contains the following seven papers: "Colorimetric Determination of Silicon in Titanium Alloys," M. Codell, C. Clemency and G. Norwitz (determination of 0.005-1.5% silicon by the molybdenum blue method after hydrolyzing most of the titanium as a crystalline precipitate from HBF_4); "Nephelometric and Gravimetric Determination of Small Amounts of Calcium in Titanium Alloys," M. Codell, A. Cherney and G. Norwitz (separation as sulfate in methanol); "Colorimetric Determination of Small Amounts of Aluminum in Titanium Alloys," M. Codell and G. Norwitz (Aluminon method); "Determination of Molybdenum in Molybdenum-Titanium Alloys by Precipitation as the Sulfide," G. Norwitz and M. Codell; "Polarographic Determination of Molybdenum in Titanium Alloys," M. Codell, J. J. Mikula and G. Norwitz; "Determination of Phosphorus in Titanium Alloys," M. Codell and J. J. Mikula (molybdenum blue method); and "Colorimetric Determination of Small Amounts of Boron in Titanium Alloys," M. Codell and G. Norwitz (separation by distillation as methyl borate, then determination with 1,1-dianthramide).—BNF. 7661

6.3.15, 3.6.6

Corrosion of Titanium and Other Alloys Studied. *Iron Age*, 171, No. 14, 178-179 (1953) April 2.

The galvanic corrosion of titanium and its alloys used in contact with another metal in a corrosive medium is not different in kind from that in other metals, although titanium is cathodic instead of anodic to most constructional metals. Test data are tabulated. It is recommended that metals close together in the galvanic series be chosen where combinations are unavoidable; that insulation be used if practical; and that both metals be coated when together. Threaded joints should be avoided if possible. Replaceable washer pieces, protective current and chemical inhibitors minimize corrosion. 7775

6.3.15, 3.7.3, 3.7.2

The Effect of Alloying Elements on Welds in Titanium. G. E. FAULKNER, G. B. GRABLE AND C. B. VOLDRICH. *Welding J.*, 32, No. 10, 481s-497s (1953) Oct.

The effects of iron, manganese, chromium and molybdenum on the mechanical and metallurgical properties of welded joints in titanium.—BNF. 7742

6.3.19, 6.3.2, 3.4.8, 3.8.4

The Rate of Dissolution of Zinc and Cadmium in Chromic Chloride Solutions. CECIL V. KING AND NATALIE MAYER. *J. Electrochem. Soc.*, 100, No. 11, 473-479 (1953).

The corrosion rate is greatly affected by the form of chromium ion present (the green dichlorotetraquo, or the purple hexaquo), the pre-treatment of the metal surface, and the pH. The rate-controlling process depends on the conditions and includes a simple chemical reaction, transport of Cr^{3+} , and an electrochemical process due to couples formed by deposition of chromium on the zinc. 15 references.—MA. 7766

6.3.20, 3.8.4

Solution Potentials of Zirconium. W. E. RUTHER AND J. E. DRALEY. Argonne National Lab. U. S. Atomic Energy Comm. Publ. (ANL-5165), December 25, 1953, 16 pp.

The solution potentials of zirconium crystal bars were measured at 50 and 315°C in gas-saturated distilled water and in other aqueous solutions. An attempt was made to correlate these potentials with the previously observed corrosion behavior of the zirconium samples in water at 315°C. No correlation was observed for any of the tested solutions. The relation between the solution potential of zirconium and that of stainless steel was observed as a function of pH at 315°C and as a function of temperature in neutral water. (auth.)—NSA. 7864

6.3.20, 4.7

Corrosion of Zirconium and Its Alloys in Liquid Metals. R. F. KOENIG. Knolls Atomic Power Lab. U. S. Atomic Energy Commission Publ. (KAPL-982). October 1, 1953, 14 pp.

Details are given of the corrosion of zirconium and its alloys in a number of common liquid metals at temperatures up to 800°C. The results are greatly influenced by the fact that the metal is a strong deoxidizer and also dissolves nitrogen and hydrogen, so that weight gains are frequently recorded in such tests. The resistance to attack by liquid bismuth, bismuth-indium-tin, bismuth-lead, bismuth-lead-indium, and bismuth-lead-tin alloys is either poor or limited at 600°C; at 300°C the resistance to bismuth-lead and bismuth-lead-tin alloys is good; at 800°C the resistance to attack by all these alloys is poor. Gallium attacks zirconium readily at temperatures greater than 100°C, forming GaZr ; mercury likewise dissolves zirconium at comparatively low temperatures. Zirconium resists attack by lithium to a limited extent at 600° and 800°C, but it has a low resistance to attack by magnesium at 655°C. Sodium, potassium, and sodium-potassium alloys do not attack zirconium at 600°C; if oxide is present in the liquid metal, an oxide coating soon forms on the zirconium. The resistance to attack by lead was good at 300°C, but limited at 600°C. Details are given of stress-rupture tests on zirconium and zirconium alloys in sodium at 540°C.—MA. 7753

6.3.20

Induction-Melted Zirconium and Zirconium Alloys. H. A. SALLER, R. F. DICKERSON, AND E. L. FOSTER, JR. Battelle Memorial Inst., Contract W-7405-eng-92, March 18, 1954, 38 pp.

Two types of zirconium and three zirconium alloys have been induction melted and their properties determined.

Sponge zirconium, iodide zirconium machine chips, Zircaloy 2, and zirconium alloys containing 2.5 and 5 wt. percent tin, respectively, were the specific materials investigated. Melting and fabrication techniques were studied, and data on hardness, electrical resistivity, corrosion behavior in 400 degrees C steam and 200, 260, 290, 315, and 360 degrees C water, and drawability were accumulated. Of the materials tested, the iodide zirconium machine-chip metal was found to have the lowest electrical resistivity at all temperatures and should be the most amenable to drawing operations. Corrosion tests in water and steam indicated that Zircaloy 2 corroded at a slower rate than did the binary tin alloys and that cold working improved the corrosion properties of all the induction-melted materials. The tensile strengths of the metal are higher than the strengths of corresponding arc-melted materials, and these higher strengths are in part explained by the presence of an iron-rich grain-boundary phase in the induction-melted stock.—NSA. 8319

6.3.20, 3.2.3

An Investigation of Scaling of Zirconium at Elevated Temperatures. 1). Quarterly Status Report No. 1, June 2 to September 2, 1953. 2). Quarterly Status Report No. 2, September 2 to December 2, 1953. W. M. BALDWIN, JR., N. J. GARIBOTTI AND E. B. EVANS. Metals Research Lab., Case Inst. of Tech. 1). AECU-2676, September 20, 1953, 5 pp. 2). AECU 2763, December 17, 1953, 5 pp.

1). The nature and cause of the high-temperature scaling and dimensional stability of zirconium are being investigated. The samples, sheared off from a cold-rolled strip, were swabbed in dilute sulfuric acid and rinsed with water and acetone. They were suspended in vertical tube furnaces and the increase in weight was determined as a function of time. It appeared that the scale appearance and color was temperature-dependent. In the range from 800 to 950 degree C the weight vs. time curve rose sharply. The plot of the parabolic scaling constant vs the absolute temperature reciprocal had a break between the high and low temperatures which was reflected in the appearance of the scales.

2). The study of the high-temperature scaling behavior of the zirconium in air was continued and the construction and assembly of special equipment to study the scaling behavior of zirconium in oxygen, nitrogen and mixtures thereof at various temperatures was nearly completed.—NSA. 8313

6.3.21, 3.2.3

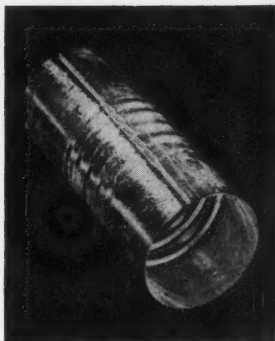
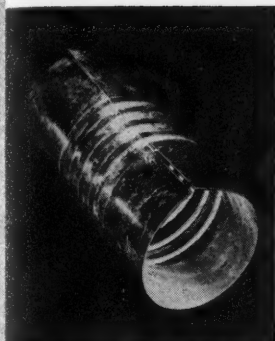
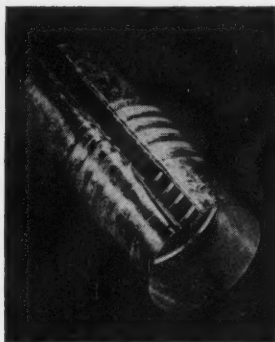
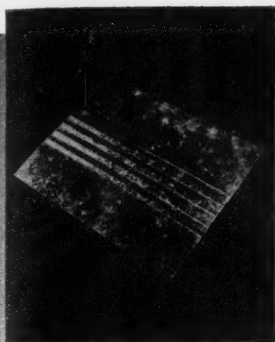
Surface Reaction Between Oxygen and Thorium. A. F. GERDS AND M. W. MALLETT. *J. Electrochem. Soc.*, 101, 171-174 (1954) April.

Rate of reaction of oxygen with arc-melted and rolled iodide thorium was found to obey parabolic rate law in temperature range of 850 to 1415 degrees C at one atmosphere pressure. Diagram, graphs, table. 13 references.—BTR. 8104

6.3.21, 3.8.3, 5.8.3

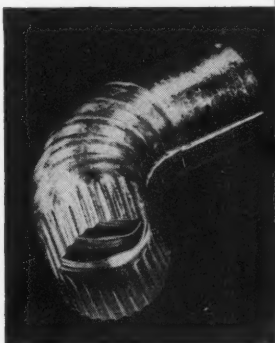
The Passivity of Thallium in Perchloric Acid, Sodium Chloride, and Sodium Sulfate Solutions. (In German). WILLI MACHU AND EZZAT M. KHAIRY. *Werkstoffe u. Korrosion*, 5, No. 1, 11-17 (1954) January.

Experiments prove two different phases occur in passivity. Diagram, graphs, tables. 9 references.—BTR. 8168



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6.4 Non-Ferrous Metals and Alloys—Light

6.4.2, 3.7.2

Studies on the Formation of Heterogeneous Coarse Crystals in Chromium Containing Light Alloys. (In French). JEAN CHINETTI. *Metaux: Corrosion-Industries*, No. 344, 151-165 (1954) April.

The presence of chromium improves the corrosion-resistance of aluminum-tin-magnesium-copper alloys. At the same time, however, it favors formation of coarse isolated crystals which leads to a decrease in mechanical properties. The dimensions of the crystals can be as large as 1 to 2 mm. Origin and formation of these coarse crystals in AX 5 GU and AZ 8 GU have been studied in the present report. The following factors contribute to the formation of coarse crystals derived from the binary phase CrAl_3 in semi-continuously cast AZ 8 GU parts: a.) the relatively poor solubility of chromium in these alloys, b.) high iron and manganese content and c.) prolonged keeping at temperatures only slightly above the liquidus which favors exaggerated crystal growth. For practical evaluation the conclusions are: I.) If the alloy contains no manganese and a small amount of iron the tendency to form primary crystals is reduced for alloys containing 0.2 percent chromium or less. This combination offers good resistance to stress corrosion. However, these alloys can only be produced from new metals. II.) For 0.3 to 0.4 percent manganese the chromium content must be kept under 0.15-0.16 percent. This solution allows the use of some scrap material. III.) Pronounced coarse-crystal formation is observed in alloys containing 0.5 to 0.6 percent manganese. In this case the chromium should not exceed 0.12-0.13 percent. This combination should be avoided because it leads to a very poor alloy due to the presence of the insoluble $(\text{FeMn})\text{Al}_3$ phase.—ALL. 8159

6.4.2, 3.7.3

The Control of Quality in the Hot and Cold Rolling of Aluminum and Aluminum Alloys. F. KING AND A. N. TURNER. *J. Inst. Metals*, 82, No. 7, 291-306 (1953-1954).

The theoretical and practical implications of the control of the UTS, bending and pressing properties, corrosion-resistance and surface finish of aluminum alloy sheet and strip are considered in the first part of the paper. In the second part, the effect of each fabricating process on the properties mentioned is described and discussed and inspection methods are considered. (auth).—MA. 8222

6.4.2, 5.3.2, 4.6.5

Static Corrosion of Aluminum Alloys at 350 Degree F and 480 Degree F in Distilled Water. P. O. STROM AND M. H. BOYER. U. S. Atomic Energy Comm. Publ., (LRL-64), Oct., 1953, 10 pp.

Static corrosion rates were measured for several commercial aluminum alloys (24S-T3, 61S-T6, 52S-O, Alclad 24S-T3 and Alclad 75S-O) exposed to distilled water at temperatures of 350 and 480 degrees F. High initial corrosion rates were observed which dropped off rapidly to nearly constant penetration rates of less than 0.3 mil/year at 350 degrees F and about 1 to 3 mils/yr at 480 de-

grees F. Alclad 24S, clad with pure aluminum was the most resistant of the alloys tested. Tables, graphs, 11 references.—NSA. 8265

6.4.2, 5.9.4

The Behaviour of Pure Aluminum and Super-Pure Aluminum in Boiling Water. (In German). D. ALTENPOHL. *Aluminium*, 29, No. 9, 361-370 (1953) September.

The surface of pure-aluminum or super-pure aluminum reacts with boiling water with the formation of a layer of boehmite ($\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$). This layer is colorless when distilled water is used but grey or black when formed in tap-water; the blackening is caused by aluminum particles loosened from the surface by etching by the tap water and embedding themselves in the boehmite layer. The reaction proceeds rapidly in distilled water and the colorless boehmite-film achieves a thickness of about 0.6μ within 1 to 2 hours. After 2 to 4 hours aging of the film occurs which transfers the layer into an acid resistant insoluble modification. After cooking for several days the boehmite layer shows a thickness of several μ . The dark colored film which first grows slowly and then more rapidly to attain a thickness of 2 to 4 μ , has the character of a corrosion product of rather loose structure and is easily soluble in acids. To avoid blackening of aluminum cooking-pans a colorless boehmite film is applied by one of the two processes described in the paper. This prevents corrosion when the pans are used for boiling tap water.—ALL. 8383

6.4.4, 3.8.3

Passivation and Activation of Magnesium in Alkali Solution. (In Russian). E. V. BARELKO AND B. N. KABANOV. *Doklady Akad. Nauk SSSR*, 90, No. 6, 1059-1062 (1953) June 21.

Determination of polarization curves for 99.95 percent magnesium with chemically pure potassium hydroxide in distilled water. Also oscillographic investigation. Graphs, 6 references.—BNF. 8342

6.4.4

Organic Finish Preferred for Magnesium Bomb Bodies. GEORGE W. GRUPP. *Org. Finishing*, 14, No. 9, 22-23 (1953) September.

Early in 1949 the U. S. Army became concerned about the corrosion of M-50 type magnesium bomb bodies. Corrosion cemented the bomb bodies to each other and resulted in pitting and flaking. An investigation carried out by Milton A. Raum, chief of the Materials Development Branch, Chemical Corps, Chemical and Radiological Laboratories, Army Chemical Center, Maryland, included the testing of lacquers, preservative coatings, preservative paper wrap and zinc chromates. The surface pretreatment of the 132 samples used included acid dipping, chemical pickling bath and mechanical buffing for the removal of grease, oil, wax, dirt and chips. Half of the samples were given a 20-months' tropical storage test and the other half were given a 140 to 250 hour salt spray test. A summary of the results is given in a table. The tests revealed that chemical or acid pretreatments are detrimental. Mechanical buffing, by wheel buffing or wire brush buffing was found to be the most effective method of preparing the surface for coating after it had been cleaned in a

Stoddard solvent and rinsed in acetone. Nox-Rust paper wax wrap was found to be an effective protection against corrosion. Chemical solutions, preventive coatings, clear lacquers and some organic coatings possessed some merit as corrosion retarders. The most satisfactory coating was zinc chromate with a dispersion type resin vehicle, overcoated with a clear lacquer.—ALL. 7933

6.4.4, 2.2.2, 2.2.7

Corrosion of Commercial Magnesium Alloys. FRED M. REINHART. U. S. National Bureau of Standards, Report No. 2519, May, 1953, 27 1.

Surface-treated and surface-treated plus painted specimens of thirty-eight commercial magnesium alloys were exposed to corrosion up to one year in tidewater and up to two years in marine atmosphere. Samples included extrusions, annealed and hard-rolled sheets, hammer and press forgings and sand and die castings. Pretreatments included chrome, acetic acid-chrome and nitric-sulfuric acid pickling, and sand blasting. Chemical-conversion treatments conforming to MIL-M-3171 included Type II with and without magnesium sulfate in the bath and with or without prior hydrofluoric acid dip; Type I with and without magnesium sulfate; and Type III. Paint coatings included two coats of zinc chromate primer MIL-P-6889 plus two coats of gray camouflage lacquer MIL-L-6805.

Based solely on the results of visual examinations, all surface treatments performed essentially similarly. All surface treatments, however, served as good paint bases for at least 24 months in marine atmosphere. Paints in tidewater protected most alloys for 12 months but failed thereafter.—PDA. 7975

6.4.4, 3.7.2

Magnesium Sand Casting Alloys Containing Thorium. K. E. NELSON. *Trans. Am. Foundrymen's Soc.*, 61, 315-326 (1953).

A study of magnesium sand-casting alloys containing 2-3% thorium plus 0.7% zirconium and in one case 2.5% zinc. Information on grain size, high temperature properties, stress rupture tests, mechanical properties at room and elevated temperatures, creep limits and corrosion resistance. These alloys are stated to have higher creep resistance at elevated temperatures than magnesium/rare-earth/zirconium.

Similar article: **The Properties of Sand-Cast Magnesium-Thorium-Zinc-Zirconium Alloys.** K. E. NELSON. *J. Metals* (Trans. AIME), Section 2, 5, No. 11, 1493-1497 (1953) November.

The effect of Th and Zn variations on the strength and 100-hr. creep characteristics of Mg-Th-Zn-Zr alloys was investigated. Optimum resistance to creep at 343 to 371 C is attainable within a certain range of Th and Zn contents. This range does not conform to that which develops maximum tensile properties.—BNF. 7919

6.6 Non-Metallic Materials

6.6.5, 4.6.11

Petrographic Investigation of Corrosion Processes of Cement. YU. M. BUT AND K. G. KRUT. *Tsement*, 19, No. 6, 16-

21, (1953); *J. Am. Ceram. Soc.*, **37**, No. 5, 85 (1954) May.

Petrographic analysis was used to determine effects of artificial sea water and 1% magnesium sulfate on clinker minerals with and without admixtures of basic and acid siliceous slags. In sea water, the destruction of Portland cement is due primarily to the formation of magnesium hydroxide and then to $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ and calcium hydrosulfoaluminate, provided there is still some unreacted $3\text{CaO} \cdot \text{Al}_2\text{O}_3$ from $3\text{CaO} \cdot \text{Al}_2\text{O}_3 + 3\text{MgSO}_4 + n\text{H}_2\text{O} = 3\text{CaSO}_4 + 2\text{Al}(\text{OH})_3 + 3\text{Mg}(\text{OH})_2$. Only then is it possible for C_3A and gypsum to be linked and for calcium hydrosulfoaluminate to form. It is also possible to have additional destruction (mechanical) because of the formation and growth of sodium chloride crystals. In 1% magnesium sulfate, the destruction of the cement is caused chiefly by the formation of calcium hydrosulfoaluminate and partly by magnesium hydroxide or $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. Upon addition of acid or basic slag, calcium hydrosulfoaluminate was not observed in sea water or in 1% magnesium sulfate, except in the case of a hydrated mixture of C_3AF with basic slag and 1% magnesium sulfate. Upon the addition of basic slag, there is formed $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, and in some cases, when sea water is added, crystals of sodium chloride appear. When acid slag is added, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ does not always form; in some cases, there were no new formations in connection with the corrosion but an accumulation of introduced aggressive salts in the form of magnesium sulfate. —INCO. 7945

6.6.6

Influence of the Wash from Bronze on the Weathering of Marble. D. W. KESSLER AND R. E. ANDERSON. U. S. Nat. Bur. Stand., Building Materials and Structure Report No. 137, 1953, 11 pp. Obtainable from U. S. Government Printing Office, Washington 25, D. C. The weathering of marble is often affected by washing from rainwater which has previously washed over bronze or copper. Different marbles are affected to a different degree, some being almost unaffected, others stained green and/or brown and in the worst cases observed, the brown stains resulted in sugaring or cracking. —BNF. 8010

6.6.4, 5.9.1

Surface Protection of Magnesium Alloys. GEORG SCHICHEL. *Metallurgie u. Giessereitech.*, **3**, 25-34 (1953); *Chem. Abst.*, **48**, No. 8, 4408 (1954) April 25.

Magnesium alloys should not be used without a protective coating. The different methods of surface protection are discussed: 1) chemical surface treatment with pickling methods; 2) autoclave treatment; 3) production of anodic coatings; 4) electrodeposition of metals; 5) lacquer coatings. Methods, equipment, and ingredients of baths are described. For short-time storage and transport 1) is sufficient (dichromate pickling); 2) gives a good protection (it produces layers with high dielectric strength). A really good protection from corrosion, however, is obtained by lacquering (lacquers of a nitrocellulose or plastic basis should be used with a previous chemical or electrolytic treatment

to produce good adhesion). Titanium white or zinc chromate are suitable pigments for the priming coat. —ALL. 7969

6.6.5, 6.6.8

Some Properties and Applications of Synthetic Resin Cements. V. EVANS. *Chemistry & Industry*, 1953, 504-509, May 23.

Considers synthetic resin cements used in corrosion-resisting constructions. —BTR. 8322

6.6.5, 8.5.1, 8.5.2

Detection of Hot Spots on the Burning Zone Shell of a Rotary Cement Kiln. D. A. WADIA. *Ind. Chemist*, **30**, No. 350, 125-126 (1954) March.

A coating of tin solder or silver solder is applied, by tinning or spraying, to the

exterior of the furnace, in the form of a pattern of 1 ft. squares. Incipient hot spots cause the coating to run. —BNF. 8290

6.6.7, 4.4.1, 4.4.6

Nitrile Rubber for Oils and Solvents. J. P. MCNAMEE. *Chem. Eng.*, **61**, No. 9, 230-238 (even pages), (1954) Sept.

Special-purpose nitrile synthetic rubbers are discussed. Since the nitriles are more expensive and more difficult to fabricate than natural rubbers, their use is limited to service conditions which require exposure to oil and solvents. Chemical resistance of vulcanized nitriles follows the general pattern set by natural rubber. Accompanying graphs serve as a guide in determining the suitability of this type of rubber for service conditions of particular interest to the reader. —INCO. 8220

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Houston, Texas

6.6.5, 6.6.8

Corrosion-Resistant Cements. V. EVANS. *Corrosion Prevention & Control*, 1, Nos. 5 & 7, 339-434, 425-427 (1954) July, Sept.

Classification of cements, including the plasticized sulfur cements, mortar, latex, synthetic resin based cements and other synthetics, is considered. Practical applications of these cements are considered for floors, channels and tanks. 13 references.—INCO. 8062

6.6.7, 5.4.3

Natural Rubber, GR-S vs. Corrosion. J. P. McNAMEE. *Chem. Eng.*, 61, No. 8, 234-248 (even pages), (1954) August.

Corrosion resistance and physical properties of natural rubber and type GR-S synthetic rubber are discussed. Uses in chemical processing for both soft and hard forms are many, and the use of rubber-lined steel is considered in particular. Resistance to various chemicals is charted.—INCO. 8204

6.6.7, 5.4.7

Stressed Rubber. A. H. WILLIS. *Trans. Inst. Marine Engrs.*, 1953, October; *J. Am. Soc. Naval Engrs.*, 66, No. 2, 504-515 (1954) May.

Paper deals with rubber as a stress-carrying material. Rubber can be used to prevent the corroding and eroding action of sea water on metallic surfaces. A technique was evolved by which rubber sheeting of 1/8-inch thickness can be bonded in large areas. Mechanical properties, rubber in shear, flexible couplings, torsional vibration, instrument mounting, cutless bearing and conductive rubber are discussed, and practical examples are given. Illustrations.—INCO. 8303

6.6.8

Polytetrafluoroethylene. Properties and Uses. L. W. CORNELL. *Mech. Eng.*, 75, 883-886 (1953).

Methods of fabrication, forms available, electrical, chemical, physical and mechanical properties and applications are discussed.—RPI. 8314

6.6.8

The Durability of Plastics Under Post Office Conditions. A. D. W. DOWNES AND A. A. NEW. *Plastics Progress*, 1953, 195-220.

Paper presented at the Plastics Convention, Olympia, 1953. Describes typical cases of failure of Post Office plastic equipment (mouldings, laminated sheet, cable coverings, etc.) including corrosion of metal insets by sulfuric acid produced by action of light on ebonite.—BNF. 8353

6.6.8, 8.8.1

PVC and Polythene for Corrosion-Resistant Plant and Equipment. V. EVANS. Paper before Symposium on Fabrication of PVC and Polythene, Coll. Tech., Birmingham, April 8, 1954. *Corrosion Technology*, 1, No. 3, 73-76 (1954) May.

Because of their corrosion resistance, PVC and polythene are used in the construction of plant and equipment ranging from beakers and valves to large gas-washing plants. Limitations of these materials are discussed and applications to fabricated structures and equipment, linings, coatings and cements are described. Brief mention is made of other modern plastics.—INCO. 8099

6.6.8, 5.4.3, 1.6

Manual for Plastic Welding. Volume II. Polyethylene. G. HAJM AND J. A.

NEUMANN. Book, 1954, 128 pp. Industrial Book Co., 1240 Ontario Street, Cleveland 13, Ohio.

This liberally illustrated book is designed for the person who wants to learn the technique of welding polyethylene materials of construction. Opening chapters explain generally what plastics are and describe the principal characteristics of common plastics. The history and development of polyethylene then are covered, with considerable attention to the material's mechanical characteristics, advantages, limitations and the shapes, thicknesses and dimensions of the parts which may be made of it.

Chapter IV gives a history of the welding of plastics, attributing discovery of the method to R. C. Reinhardt of Dow Chemical Company in 1937. Succeeding chapters describe and illustrate welding equipment, explain details of the process in step-by-step fashion, describe the types of welds suitable for polyethylene, lining of tanks, fabrication of pipe lines and fittings and the scope of fabrications and industrial applications of the material. The appendix includes a table giving resistance of the materials to various concentrations and temperatures of corrosives.

6.6.8, 5.4.8

Polytrifluorochloroethylene for Corrosive Service. J. A. JUPA. M. W. Kellogg Co. *Chem. Eng.*, 61, No. 6, 272, 274, 276, 278 (1954) June.

Kel-F, a trifluorochloroethylene polymer is outstanding in its chemical resistance to corrosive agents such as fuming nitric acid, hydrofluoric acid, peroxides, mineral acids, alkalis and organic solvents. It is produced in molding powders, dispersions, oils, greases, and waxes. Its applications are gaskets, seals, containers, diaphragms, liners, filters and coatings for corrosive and thermal service. A 5-8 mil thickness of film in chemical drum and pipe liners permits use of carbon steel instead of expensive alloys. Tables of physical and mechanical properties of chemical resistance and stability to corrosive agents, illustrations.—INCO. 8216

6.7 Duplex Materials

6.7.2

Bonding in Cermet (Ceramic-Metal Systems). L. S. WILLIAMS AND P. MURRAY. *Metallurgia*, 49, No. 295, 210-217 (1954) May.

The criterion for selecting promising cermet materials is the likely bonding behavior between the metal and the ceramic phase. The surface tension of the liquid metal is of primary importance, and authors have shown that by various methods it is possible to modify surface tensions so as to achieve wetting in systems involving refractory metals with high melting points.—BNF. 8287

6.7.2

Cemented Carbides with High Resistance to Corrosion and Scaling. Part I: Corrosion-Resistant Cemented Carbides. JOSEF HINNBERGER AND OTTO RUDIGER. *Arch. Eisenhüttenw.*, 24, No. 5-6, 267-269 (1953).

Development work on corrosion and wear-resistant cemented carbides based on chromium carbide with nickel as a binder. Physical properties of known chromium carbides. Results of metallographic and X-ray studies conducted

to obtain basic data for the chromium carbide-nickel and the chromium carbide-cobalt phase diagrams. Particulars on a chromium carbide + 12% nickel composition, mechanical and physical properties, thermal expansion coefficient compared with that of steel. Results of authors' corrosion tests in various acids. Suitability of new carbide for brazing onto steel and for hard facing of steel, in the light of preliminary tests. Translation available: Henry Brucher, P. O. Box 157, Altadena, Cal. 7921

6.7.2, 3.2.3

Pressure Sintering of Zirconium Carbide: Some Results of Preliminary Tests of the Resistance of Carbides to Oxidation. W. WATT, G. H. COCKETT, AND A. R. HALL. *Metallurg. Corrosion-Industries*, 28, No. 333, 222-237 (1953).

The construction and operation of presses designed for pressure sintering of carbides by 1) HF induction or 2) resistance heating are described. Values of apparent α , electrical resistivity and bending-rigidity for ZrC compacted and sintered at 1500, 1600, 1700 and 1900C are tabulated, together with the respective loss of weight experienced by ZrC, VC, TiC, TaC, Cr₃C₂, NbC, and B₄C when heated for 1/2-hour in a stream of air at 800C. Carbides of titanium, vanadium, niobium and tantalum can be sintered by compacting in graphite matrices at 2000C; chromium carbides can be similarly sintered at 1350C. In order to obtain sintered carbides of low porosity, the powders used should have a small grain-size. The maximum mechanical strength of sintered ZrC is of the order 20-24.1 kg./mm² and can be attained before sintering is complete if the degree of sintering is ascertained by measuring the electrical resistivity of the compact. Cr₃C₂ is resistant to oxidation up to 1000C at least; sintered TiC is characterized by a linear rate of oxidation at 900 and 1000C for a period of 100 hours, but the rate is not sufficiently low for this carbide to find practical application. Sintered carbides of zirconium, vanadium, tantalum and niobium, of industrial purity, oxidize rapidly in dry air at 800C. 28 references.—MA. 8021

6.7.2, 5.4.2

High-Temperature Protection of a Titanium Carbide Cermet. JOHN R. WILSON. *Bull. Amer. Ceram. Soc.*, 32, No. 11, 375-376 (1953); Cf. U. S. Advisory Comm. Aeronaut. Tech. Note 2386, 1951.

80:20 titanium carbide-cobalt cermet has satisfactory strength for gas-turbine applications but oxidizes appreciably after 10 hours service at 1600F (900C). A coating of 10:90 high-silica and baria frit-chromium improves the corrosion-resistance markedly, as well as the thermal-shock resistance. The coating is applied by dipping the cermet part in a slip and firing to 2200F (1200C). Coated specimens showed no appreciable loss in thickness after a 50-hour test at 2200F. A graphical representation of data indicates that a) uncoated specimens scale at an increasing rate with increasing temperature, whereas the rate for coated specimens is approximately constant at 1700-2100F (925-1150C); and b) coated and uncoated specimens scale at about the same rate at 1650F. The coating has satisfactory high-temperature ductility.—MA. 7905

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1, 8.9.2, 4.4.6

The Mechanism of Corrosive Wear in Passenger-Car Service. J. G. RYAN AND B. W. DELONG. Paper before Am. Petroleum Inst., Div. Refining, 18th Mid-Year Mtg., Session on Lubricating Oils, N. Y., May 14, 1953. *Proc. API*, 33, Sect. III-Refining, 216-221 (1953).

Operational and fuel factors involved in the gasoline engine-wear problem are considered. Chemical roughening of the rubbing surfaces, as a result of corrosive attack by acids has an adverse effect of serious proportions on wear rate. Field tests showed that when mileage was accumulated at the rate of 500 miles per month, wear was about 4 times greater than in 1500-miles-per-month service. These results can be accounted for on the basis of laboratory-engine studies on the influence of jacket-water temperature. Fuel sulfur content is one factor which affects ring wear. Motored-engine tests were conducted in which sulfur dioxide and trioxide and water vapor were injected at various jacket temperatures. Results indicate that virtually all the corrosive wear caused by fuel sulfur can be accounted for by sulfurous rather than sulfuric acid attack. Sulfur dioxide had little effect on wear unless conditions were favorable to water condensation. Illustrations, discussion, 8 references.—INCO. 7965

Wear in Bearings. C. H. JUNGE. Cleveland Graphite Bronze Co. Paper before Am. Soc. Testing Materials, Symp. on Engine Lubrication, Ann. Mtg. 1953. *ASTM Bull.*, No. 198, 64-69 (1954) May.

Various types of wear, including fatigue scoring, wiping, seizure, corrosion and erosion, encountered in sleeve bearings under many conditions of service are described. Methods of recognizing different types of bearing failures, as well as corrective measures which can be employed to eliminate or reduce sleeve bearing troubles, are outlined. Examples of the various failures are illustrated. Microsections through corroded lead base Babbitt, copper-lead and leaded tin bronze are shown.—INCO. 8139

Metallurgical Aspects of High Temperature Steam and Gas Turbine Plants. J. M. ROBERTSON. *Trans. North East Coast Inst. Engrs. Shipbuilders*, 70; No. 5, 4, 5; 217-252, d93-d120 (1954) Feb., March.

Importance of creep, fatigue, relaxation, thermal stress, and corrosion resistance; heat treatment; high temperature alloys (steels, Nimonic and other nickel alloys, cobalt alloys); welding; composition of various proprietary alloys.—BNF. 8386

7.1

The Kaplan Turbine—Design and Trends. J. FISCH. Paper before Am. Soc. Mech. Engrs., Ann. Mtg., N. Y., Nov. 29-Dec. 4, 1953. *Trans. ASME*, 76, No. 5, 765-773; disc., 773-774 (1954) July.

Adjustable-blade propeller turbine, known in the hydro-power industry as a Kaplan turbine, is discussed. Runner blades, usually of cast steel are pro-

tected from cavitation by weld overlay with 18-8 Type 308 coated weld rods, or by cladding with 18-8. Wicket gates are made of cast steel with longitudinal sealing edges of the gates protected against corrosion and pitting with stainless steel. Main shaft is of forged steel.—INCO. 8100

7.1, 4.2.3, 4.3.3, 5.10

Control of Combustion as a Means of Influencing Oil Ash Deposition in Industrial Gas Turbine Installations. (In German). P. T. SULZER. *Schweiz. Archiv angew. Wiss u. Tech.*, 20, No. 2, 33-41 (1954) February.

Attack of molten vanadium pentoxide on steel. In incomplete combustion carbon, sodium compounds and alkaline earth compounds tend to inhibit corrosion. An elaborate table gives physico-chemical data on the combustion products of metal compounds often present in heavy oils (vanadium, sodium, calcium, magnesium, aluminum).—BNF. 8352

7.1, 4.3.3, 4.2.3, 5.8.2

Corrosion Aspects of Bunker C Combustion in Gas Turbines. B. O. BUCKLAND AND C. M. GARDNER. Gen. Electric Co. *Proc. Am. Power Conf.*, 15, 237-244 (1953) March 25-27.

30,000 hr. of Bunker C-burning gas turbine operation has shown that a corrosion problem exists when burning residual oil because the presence of slag-forming substances will very likely corrode the metallic parts. Timken-materials oxidize at temperatures above 1500 degrees F so first-stage nozzles with 25% chromium-20% nickel alloy partitions were made. History of operating experience and laboratory and shop corrosion tests are briefly described. Most of the testing and research work was done on a 28% chromium alloy. Crucible tests indicate that vanadium pentoxide and sodium sulfate are the most corrosive agents found in appreciable quantities in any of the oil ashes examined. For inhibiting corrosion by vanadium pentoxide, calcium, magnesium, strontium, barium or nickel compounds all appear to be good. The fact that nickel serves as an inhibitor for vanadium corrosion is probably consistent with the fact that practically all high-nickel alloys had poor resistance to vanadium corrosion. It may be postulated that vanadium has a high affinity for nickel so when the latter is introduced as an additive it ties up with the vanadium and prevents further corrosion; whereas, when it is present in any alloy exposed to vanadium, in certain temperatures at least, the nickel is attacked. Sodium sulfate and vanadium pentoxide to some extent inhibit one another and a sodium-containing oil relatively free from vanadium will have a more corrosive ash than one containing the same of sodium and approximately three times as much by weight of vanadium as sodium. Table describing the character of ash is included. Illustrations, 5 references.—INCO. 8355

7.1, 4.4.6, 2.3.1

A Broad Look at Engine-Oil Testing. G. H. S. SNYDER, E. A. MARTIN, L. RAYMOND AND J. F. SOCOLOFSKY. Paper before API, Div. Refining, 18th Mid-Year Mtg., Session on Lubricating Oils, N. Y., May 14, 1953. *Proc. Am. Petroleum Inst.*, 33, Sect. III-Refining, 184-201 (1953).

Background and present state of

engine-oil testing are reviewed. Introduction of passenger-car engines equipped with hard-alloy (copper-lead, cadmium-silver, cadmium-nickel) bearings which were found to be susceptible to corrosion and failure under prolonged high-speed driving conditions stimulated the importance and growth of engine-oil testing. Significant performance properties of oils are discussed and the influence of engine design, operating conditions and fuel on oil performance are described. Field and laboratory results are compared and information on a Socony-Vacuum cyclic engine test is presented. Socony-Vacuum uses the Lauson LF engine tests (includes bearing-corrosion and detergency tests) as preliminary tests. Limitations of laboratory tests are considered. Illustrations, tables, 16 references.—INCO. 8193

7.1, 4.4.7

Engine Wear as Affected by Lubricant Composition. H. C. MOUGEY. Paper before Am. Soc. Testing Materials, Symp. on Engine Lubrication, Ann. Mtg., 1953. *ASTM Bull.*, No. 198, 57-63; disc., 63-64 (1954) May.

Factors involved in corrosive wear are discussed and the theories developed as a result of lab tests have been verified in service tests in individual cars and in fleets in actual service on the road. Operating conditions in which corrosive wear may be serious are typical of stop-and-go and intermittent service. Corrosive wear, engine wear as measured by oil consumption, importance of corrosion-resistant oils, problem of testing for corrosion resistance, importance of high film strength or extreme pressure properties, and additives, are covered. Tables, graphs and illustrations.—INCO. 8169

7.1, 5.3.2

Piston Rings for Pipeline Engines. J. W. PENNINGTON. Koppers Co., Inc. *Diesel Power*, 32, No. 6, 46-48 (1954) June.

Factors to be considered in selection of piston rings. Chromium plated rings reduce wear on cylinder to one-half or less of the wear found with conventional ring. Chromium plating up to .030-in on the face has been applied to some large rings. If breakage is encountered the use of a high-strength material such as malleable iron or ductile iron may be indicated.—INCO. 8255

7.1, 5.3.2

Surface Treatment of Light-Alloy Pistons. (In Italian). A. PRATI AND F. SACCHI. *Alluminio*, 23, No. 2, 139-144 (1954) March.

The problem of surface protection in light-metal pistons has been resolved for Otto four-stroke cycle engines by applying protective coatings. Anodic oxidation has been almost completely abandoned in recent years. For normal protection tinning has been adopted. In Germany lead coating and graphitization are used for finishing light-metal pistons. In diesel motors neither tinning nor lead coating is acceptable because both tin and lead catalyze decomposition of the oil.—ALL. 8251

7.1, 6.2.1, 4.2.3, 3.5.9

Metals Used at High Temperatures. J. M. ROBERTSON. (J. Birmingham Met. Soc., Golden Jubilee (1903-1953), Special Issue, 185-200 (1954) June.

Review of materials used in steam and gas turbine plants (400-950 degree C),

properties required and methods of assessing them and reactions of materials with ash constituents (general notes on mechanism of vanadium pentoxide attack). Prospect of solving problem of ash corrosion by altering composition of heat-resisting alloys does not seem very promising. Critical chromium contents and temperature ranges in which they are operative and effective treatments and compositional adjustments to produce maximum performance are discussed. Compositions, properties (especially creep behavior) and fields of application are given of: steels derived from mild steel (hardenable ferritic steels with low or moderate resistance to oxidation); steels derived from stainless iron (hardenable ferritic steels with good resistance to oxidation); non-hardenable ferritic steels with excellent resistance to oxidation; austenitic steels based on iron-chromium-nickel alloys; nickel-base alloys; a.) intended primarily for oxidation-resistance and b.) alloys with good high-temperature properties; and cobalt-base alloys. Section on sigma phase and development of materials such as R. ex 467 materials are included.—INCO. 8273

7.1, 8.9.5, 3.5.3

How to Reduce Diesel-Cylinder Liner Corrosion. F. J. McCloud. *Marine Eng.*, 59, No. 8, 50-51, 80 (1954) August.

Study of Diesel-engine cylinder liners of ocean-going ships, troubled with cavitation erosion, is reported. Causes are analyzed and preventive measures investigated. Results show that reducing vibration, treating water with proper corrosion inhibitors, using more resistant liner material, and reducing opportunities for vacuum-cavity formation are important means of minimizing damage to liners.—INCO. 8145

7.2 Valves, Pipes and Meters

7.2

Valves to Combat Corrosion. *Chem. Eng.*, 61, No. 9, 198-204 (1954) Sept.

Seventy-five questions and answers submitted to recent valve clinic sponsored by the Cooper Alloy Foundry Co. covered selection of proper valve materials for corrosive service. Properties of materials that will make them suitable for valve construction from a mechanical standpoint also are considered. Cast alloys referred to, with their equivalent wrought types, include CF-8 (18-21% chromium, 8-11% nickel), CF-8M (18-21% chromium, 9-12% nickel, 2-3% molybdenum), CF-8C (18-21% chromium, 9-12% nickel, niobium) and CN-7MCu (18-22% chromium, 21-31% nickel, molybdenum-copper). Ilium, Hastelloy C, Monel and nickel are also reported for various corrosive services. Tables.—INCO. 8069

7.2, 8.8.1, 5.11

Selecting Gaskets to Limit Corrosion of Stainless Steel Bolted Joints in a Chemical Plant. E. V. KUNEL. *Corrosion*, 10, No. 8, 260-266 (1954) August.

Examples of corrosion of austenitic stainless steel joint surfaces attacked by liquid media penetrating gaskets are described. The author postulates liquids of high electrical conductivity containing weak oxidizing and reducing agents are principally responsible for the pitting attack of the gasket bearing surfaces. Presence of chloride salts or organic chlorides in the gasketing material may contribute to stress corrosion cracking

of the joint surface. Graphite seems to have no major influence although in some cases it may tend to aggravate the attack.

Corrosion is attributed to pools of liquid wicked through the gasket via fibers, as in gaskets with asbestos fiber fillers. Wicking by short fiber fillers is less than by long fibers. The small pools of liquid create active passive and/or oxygen concentration cells with the entire inside surface of equipment as cathodic areas. This imbalance tends to accelerate pitting. Control is achieved by using gasket materials without wicking constituents or which have continuous exterior surfaces of non-wicking material. Alteration of the process chemicals and application of a barrier coating between the gasket and the bearing surface of the joint were considered as control measures but not tested. Tests using 37 gasket materials compressed in racks suspended in the process stream showed non-fibrous materials to be superior.

Correct joint design is essential to reduce crevices which permit process liquid to seep between the gasket and the bearing surface. The author recommends that all mating surfaces be machined, that design prevent bolt-load from deforming gasket usurfaces and that build-up stainless steel mating surfaces on carbon steel joints be avoided. Examples of correct and incorrect joints are shown. Testing gasket materials before use is recommended. 8024

7.2, 8.10.3

A Mile of Stainless Steel . . . Corrosion-Resistant Pipe Installed in Northern Mines. *Canadian Metals*, 17, No. 9, 33-34 (1954) August.

Welland Electric Steel Foundry Ltd. has fabricated over a mile of corrosion-resistant stainless steel pipe for installation in several northern Canadian mines. Type 304 is rolled or formed to correct diameter, tack-welded and made up to various lengths after which flanges are tacked on. After passing pressure test, pipe is submerged in a hot nitric acid bath for passivating.—INCO. 8074

7.2, 4.6.1

Corrosion and Silting in Water Meters. P. SCANES. *Instrument Engr.*, 1, 69-71 (1953) October.

Discusses meter design, effects of different waters, materials of manufacture and interference from foreign matter. Photographs, diagrams.—BTR. 7880

7.2, 7.10

Look Into Your Culverts. J. F. JOHNSON. *Highway Mag.*, 44, 279 (1953) Dec.

A number of culverts in West Virginia were critically inspected. Almost all those examined—including types galvanized, galvanized bituminous-coated and galvanized bituminous-coated with paved invert will greatly exceed the lives originally predicted. It is suggested that if the effluent carried has a pH value of from 6.0 to 8.0, plain galvanized pipe should last at least 50 years; where the pH is 4.0 to 6.0 the bituminous-coated, paved invert type should have a similar life. If a low pH value is encountered, an asbestos-bonded, full coated, paved-invert culvert should be used.—ZDA. 7954

7.2, 7.1, 6.3.10

Research on (Nickel Alloy) Exhaust Valves of Aeroplane Engines. E. H. BUCKNALL AND F. A. BALL. *Rev. Met.*,

49, No. 4, 249-261, disc. 261 (1952).

Aeroplane engine valves are subjected to severe stresses and to the action of very corrosive agents, such as doped octane, at temperatures appreciably above their nominal working temperature at 600°C. In England DTD 49B steel is usually used for valves and the crowns are faced with Brightray (80:20 nickel-chromium). Care is required to obtain a suitable facing and this is done with an oxyacetylene torch using a reducing flame and no flux. The effect of impurities picked up by the Brightray alloy and the nature and cause of defects occurring in service are discussed. The hardness of the DTD 49B steel is slightly less than that of Brightray, but it loses its hardness rapidly above 600°C, whereas Brightray maintains its hardness to at least 700°C. The usual creep tests could not be carried out owing to the difficulty in preparing suitable specimens but Brinell hardness tests were carried out with a special steel ball on disc-shaped faced and unfaced specimens contained in a furnace and heated to 650 and 750°C for 48 hours. These showed that the unfaced steel specimens are much less resistant than complete discs of Nimonic 75 and tend to be rather less resistant than Brightray-faced discs. There appear to be three methods of improving the facing alloys: 1) modification of the nature and quantity of carbides to obtain a) a matrix less impoverished in chromium and hence more resistant to corrosion, and b) a higher proportion of hard constituents in the micro-structure; 2) modification of the solid-solution phase in the matrix by the use of addition elements that enter into solution in the nickel-chromium alloys; 3) a combination of these two. The use of niobium and titanium for stabilizing the carbon were disappointing. Experiments on the effect of cobalt and tungsten as addition elements were not proceeded with, owing to harmful effects of these elements in other respects.—MR. 7912

7.3 Pumps, Compressors, Propellers and Impellers

7.3

Oil Pump Design in the U.S.A. Report by O.E.E.C. Tech. Assistance Mission No. 57. *Fluid Handling*, No. 43, 216-218 (1953) August.

Discussion on refinery pump design and fabrication and impellers and other fittings with reference to materials of construction of pumps for refinery service, impellers, wearing rings and shafts, shaft sleeves and packing glands. Materials considered include cast iron and iron alloys, cast and forged steel, 4-6 and 11-13% chromium stainless steel, 18-8, Monel, bronze, chromium-nickel iron, carbon steel and case hardened steel.—INCO. 8378

7.3

The Corrosion-Metallurgical Aspects of Sucker Rods and Their Oil Well Service Performance. F. J. RADD AND R. L. MCGLOSSON. *J. Petroleum Technology*, 6, (Trans. Am. Inst. Mining Met. Engrs., 199), 37-44 (1954) March.

Mechanisms of corrosion and corrosion fatigue damages examined from a fundamental electro-chemical viewpoint. Relationships of sucker rod micro-structures to these damaging effects. Diagrams, photographs, micrographs. 15 references.—BTR. 8272

7.3 Corrosion of Bronze Oil-Sealing Sleeves in Centrifugal Gas Compressors.

EDWARD C. GRECO, *Corrosion*, 10, No. 9, 279-283 (1954) September.

Pipe line dust was suspected as the reason for the frequent failure of phosphor bronze oil-sealing sleeves in centrifugal gas compressors when analyses of oil from the sealing systems showed appreciable quantities of iron sulfide. This was picked up, along with iron oxide and silica, from pipeline dust created by the passage through the line of steel wirebrush scrapers. Corrosion product resulting from the attack by this dust clogged up oil passages and caused failure of the sleeves.

Laboratory tests with oil from the seal oil system were made with copper strips. These tests indicated the dusts picked up by the oils were responsible for the corrosion.

Tests with both seal oil and scrubber oils on mild steel, aluminum, Monel, Inconel and nickel showed these suffered no attack. A cellulose-type filter was substituted for the previously used Fuller's earth filter in the seal oil system and after 7 months' observation was found to be substantially more efficient than the Fuller's earth. Meehanite oil seal rings were substituted for the phosphor bronze sleeves and the failures due to iron sulfides were eliminated. 8109

7.3, 4.6.11

Cast Monel Impeller. *Materials & Methods*, 39, No. 3, 114 (1954) March.

Impeller, cast in S Monel by Inco, will be used to pump 120,000 gal. of sea water per min at a total discharge head of 10.5 ft. It was cast for a large chemical company to maintain proper circulation of water in condensers for the turbine generator in connection with the extraction of magnesium and other chemicals from sea water. Alloy was selected to withstand the corrosive and abrasive attack of the water. Illustrated. —INCO. 8181

7.4 Heat Exchangers

7.4.2, 4.6.11

The Resistance to Failure of Condenser and Heat Exchanger Tubes in Marine Service. P. T. GILBERT, *Trans. Inst. Marine Engrs.*, 66, 1-6; disc., 6-20 (1954) January.

Types of corrosion causing failures. Development of resistant alloys. Table, photographs, micrograph. 25 references. —BTR 8114

7.4.2, 4.2.3

Design and Operation of High-Recovery Regenerative-Type Air Preheaters. Parts I & II. G. BRADDOCK AND J. WAITKUS, Air Preheater Corp. Paper before ASME, Fall Mtg., Rochester, Oct. 5-7, 1953, *Trans. Am. Soc. Mech. Engrs.*, 76, No. 5, 697-712; disc. 712-714 (1954) July.

Operation of high-recovery regenerative-type air preheaters from the standpoint of removing deposits and controlling metal temperature is covered. Control of corrosion, therefore, requires control of the accumulation of deposits and the formation of moisture. Constituents such as sulfur, vanadium, ash and moisture are recognized as basically responsible for difficulties with deposits. Cold-layer heating elements, packed in baskets convenient for handling are fabricated from 18-gage corrosion-resistant low-alloy steel. Baskets are reversible so that the portion of elements thinned by corrosion can be turned away from the zone of corrosion and the unaffected portion exposed to it. Attention is being directed to coating the ductwork beyond the preheater as protection against deterioration from corrosive conditions created by flue gases. Cement or ceramic has been considered. Graphs and diagrams.—INCO. 7981

Progress report on a continuing test of superheater-tube materials, the arrangement and testing environment of which closely approach those of a practical superheater installation, is given. Tube materials include AISI 304, 347, 321, 316 and 318 stainless steels. Timken 16-25-6, Armco 17Cr14NiCuMo and a new experimental superstrength alloy, Croloy 15-15N. High temperature corrosion behavior, microstructural changes and changes in mechanical properties of the various alloys are discussed. Tables, micrographs and graphs.—INCO. 8091

7.4.2, 4.6.2

Experimental Superheater for Steam at 2000 Psi and 1250°F.—Progress Report after 12,000 Hours of Operation.

F. EBERLE, F. G. ELY AND J. A. DILLON, Babcock & Wilcox Co. *Trans. Am. Soc. Mech. Engrs.*, 76, No. 4, 665-675; disc. 675-677 (1954) May.

7.4.2, 5.4.2

Test of Ceramic-Coated Air Heater Tubes. J. P. GALLAGHER, *Combustion*, 25, No. 12, 61-62 (1954) June.

Six months' test under actual operation.



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ing conditions proved that ceramic-coated steel tubes reduce operating costs and maintenance problems of air preheater tubes in power plants. Vitralloy tubes were compared to plain steel tubes. No residue was apparent on the surfaces of the Vitralloy tubes after hot water immersion test. A continuous unbroken vitreous appearance was presented except at the outer edge engaged inside the plain steel sleeve, due to initial corrosion in the unprotected sleeve wall.—INCO. 8063

7.4.2, 5.4.8

Topic of the Month. A Method of Protecting Heating Coils in Some Corro-

sive Solutions. G. G. SCHMUCK AND R. W. FLOURNOY. *Corrosion*, 10, 231 (1954) Aug.

Fluorocarbon plastic materials found useful in many corrosives at temperatures up to 400 degrees F. Heat transfer loss is insignificant. Photograph.—MR. 8361

7.5 Containers

7.5.2, 8.3.5, 6.4.2

Preliminary Report on the Possible Use of Aluminum Cans for Fruit and Vegetables. W. B. ADAM. *Refrig. J.* (Melbourne), 6, 32, 34-35 (1953) May; *Chem. Absts.*, 47, No. 21, 11104 (1953) Nov. 10.

Discussion of relative merits of aluminum and tin-plate cans with the conclusions that for vegetables aluminum has an advantage in not producing dark sulfur stains with vegetables such as peas and turnips and if lacquered (and preferably anodized) seems to give no more trouble from hydrogen swells than lacquered tin plate. For acid products such as fruits, aluminum is too readily corroded. Aluminum cans are lighter than tin plate but more readily damaged. Traces of aluminum or tin normally present in cans after processing were non-toxic. Products from the two types of cans showed little difference in color or flavor. Factors of cost and availability favor tin plate at present.—ALL. 8323

7.5.4, 5.2.2

Badly Corroded Holder Lift Plates Speedily Restored by In-Service Repairs. M. C. MCCALLUM. *Gas*, 30, No. 3, 40-42 (1954) March.

Rivet and plate deterioration and stress corrosion on holder lift plates necessitated a major repair job at Seattle Gas Co. Metal and rubber patches were applied to stop the gas leaks. Problem of preventing further corrosion was tackled. Since galvanic corrosion was suspected as the cause, the decision was made to install zinc plates for anodic protection.—INCO. 8157

7.5.5, 4.4.6, 5.8.2

Internal Corrosion in Domestic Fuel Oil Tanks. R. WIELAND AND R. S. TRESEDER. *Corrosion*, 10, No. 11, 401-406 (1954) November.

Failure of domestic fuel oil tanks by perforation at the bottom as a result of internal corrosion has been a troublesome problem of the oil industry. Field investigation indicated the primary cause of corrosion to be the presence of small amounts of water in the tanks but did not provide a satisfactory explanation for the rapid localized attack that would occur sporadically. Laboratory data are presented which show that very rapid penetration can result from localization of the rusting action of water if imperfect coatings are present on the surface of the steel. Examples of such imperfect coatings are mill scale with breaks in the scale, thin sludge deposits and dirt collected on the bottom of the tank. There was no indication that the fuel oil was contributing any corrosion accelerating acidic constituents.

Addition of an alkaline sodium nitrite mixture to the individual tanks has been proved to be an effective means of preventing these corrosion failures. Supporting laboratory data are presented. 8229

7.5.5, 4.6.6

Prevention of Corrosion in Mineral Oil Storage Tanks. (In German). H. E. FOOTNER. *Schweizer Archiv. fur angew. Wiss. u. Tech.*, 20, No. 3, 72-75 (1954) March.

Preparation and coating of inside and outside of storage equipment.—MR. 8098

7.5.5, 5.2.1

Cities Service Lays Gulf Coast Line. H. NELSON. *Oil Gas J.*, 53, No. 20, 212, 214, 219 (1954) September 20.

Features of the new system include use of sloping tank bottoms, which permit pumping the tanks down to a low level when necessary to change from sour-crude to sweet-crude service, and also minimize corrosion. Bottom is coated with mastic and supplemented with magnesium anodes. All outside surfaces of floating roof are treated with zinc-base protective coating, while the surfaces of tank shells are painted white with an epoxy primer and two vinyl finish coats. Tank rests on a reinforced concrete ring padded with asphalt and felt. Undersides of tank bottom are protected by a cathodic system.—INCO. 8256

7.5.5, 6.6.8, 4.6.6

Corrosion-Resistant Plastic Tanks Have Great Strength. A. GIBBON. *Pipe Line Industry*, 1, No. 3, 78-79 (1954) Sept.

Plastic tanks are being used successfully in areas where sour crude oil poses serious storage problems. Highly resistant to corrosion, they are being designed for oil leases, pipe line tank farms and for refineries and petrochemical installations. Tanks made from the polyester resin resist action of hydrogen sulfide as well as most acids. Tables.—INCO. 8102

7.6 Unit Process Equipment

7.6.5, 8.3.6, 5.9.2, 5.9.3

Descaling of Evaporator Heating Surfaces in Cane Sugar Factories. N. O. SCHMIDT AND L. F. WIGGINS. *Ind. and Eng. Chem.* 46, 867-870 (1954) May.

Experiments on prevention and removal of scale by chemical and mechanical means. Tables, photograph. 3 references.—MR. 8280

7.6.6

Comparative Analysis of Digester Corrosion Measurements. A. UNGAR AND T. E. CAYWOOD. *Tappi*, 37, 177-190 (1954) May.

Bulk of data supplied by alkaline pulp mills; analysis has concentrated on these. Tables, graphs, 15 references.—BTR. 8246

7.6.6

Comparative Analysis of Digester Corrosion Measurements. TAPPI Digester Corrosion Subcommittee Summary Report No. 1. NICHOLAS SHOUMATOFF AND H. O. TEEPLE. *TAPPI*, 37, 166-171 (1954) April.

Industry-wide study of corrosion in alkaline digesters by numerical analysis of over 37,000 wall thickness measurements in 89 digesters in twelve different mills. Tables, graph. 12 references.—BTR. 8274

7.6.8

Turbogrid Distillation Trays. R. B.

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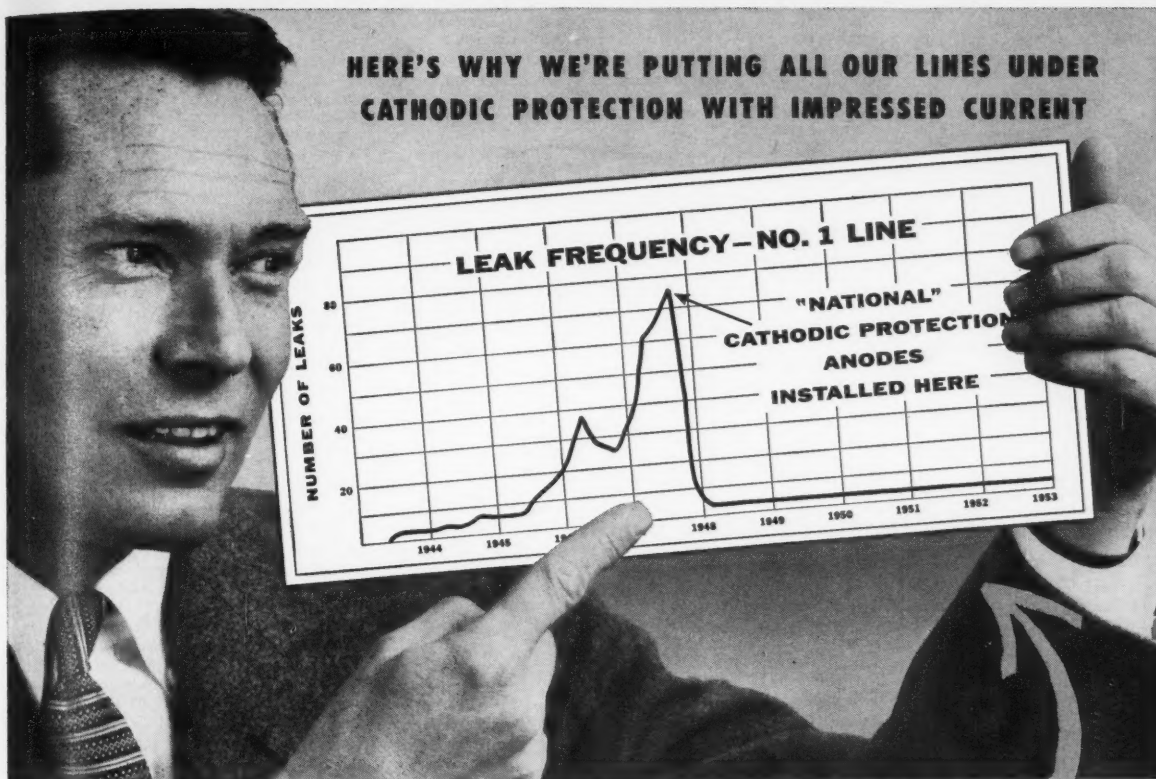
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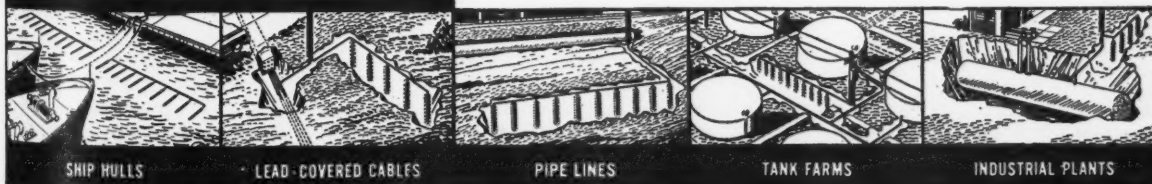
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OLNEY. Shell Dev. Co. Paper before Am. Inst. Chem. Engrs., St. Louis Mtg. *Chem. Eng., Progress*, 50, No. 2, 57-64 (1954) Feb.

Turbogrid trays, a new type of vapor-liquid contacting tray, were introduced to industry as a result of research on distillation equipment. They have exhibited less tendency toward fouling and corrosion than with bubble-cap trays and have been successfully fabricated from copper, Karbate, copper-nickel, or ceramic.—INCO. 8298

7.6.9, 5.3.2, 5.11

Potentialities of Stainless-Lined and Stainless-Clad Steels for Pressure Vessels. B. GOEDHUIS. Paper before 5th Symposium on Materials of Construction for the Chemical Industry (Clad Materials), sponsored by Dutch Chemical Soc. and Royal Dutch Inst. Eng., Nov., 1953. *Ingenieur*, No. 16, 18, 20-22 (1954); *Chem. Tech.*, No. 4-7, 25-32; disc., 32-33 (1954).

Data on 18/9 and 18/10 stabilized chromium-nickel types, 17/12/2.5 chromium-nickel-molybdenum, 25/20 chromium-nickel and 12.5 and 17 percent chromium steels. Notes on stress effects occurring due to differential expansion of stainless steel and carbon steel, formulae for calculation of extra stresses in plate material and in weld seams, particulars of method developed for calculation of wall thickness of pressure vessels in stainless-lined and stainless-clad steels and comments on data published in *Trans. Am. Soc. Mech. Engrs.*, 1952, relating to reactor in clad steel for catalytic cracking installation are given.—INCO. 8370

7.7 Electrical-Telephone and Radio

7.7

Contact Phenomena in Sealed Containers. R. H. GUMLEY. Bell Telephone Labs. *Bell Labs. Record*, 32, No. 6, 226-230 (1954) June.

Organic vapors seriously shorten the life of an eroding contact as shown by tests of relays in sealed containers. With heavy vapor contamination lead contacts are eroded to a large extent, the erosion taking the form of full area wear on the negative contact, leaving the positive virtually unaffected. Compared to lead, the net loss of contact metal of silver is very small. Illustrations, graphs.—INCO. 8090

7.7

Factors Affecting the Choice of Finish for Electrical Equipment. E. C. J. MARSH. *Electroplating*, 7; Nos. 3 & 4; 88-91, 132-135 (1954) March, April.

A discussion on the factors influencing the choice of finish for electrical equipment, with emphasis on the need to avoid corrosion at the junctions of dissimilar metals. The contact potentials for a number of metals and alloys are listed, and a second table shows metal-to-metal combinations which have been found satisfactory in practice. The suitability of a number of metallic finishes, including zinc and cadmium, for the protection of electrical equipment is discussed. Some examples from practice are given. 8179

7.7

Design and Construction of Needle

Thermocouples. W. G. RAUCH. *Metal Progress*, 65, No. 3, 71-74 (1954) March.

Many difficulties in manipulation (owing to bulk of standard two-wire thermocouples) are overcome in the needle type, in which an insulated wire as one component is inserted into a tube as the second component, the hot junction between rod and tube being formed by welding. Size can be reduced to a minimum by using hypodermic needle tubing. Design and assembly is described, with tests for the following combinations: stainless steel-aluminum, stainless steel-copper, Kovar (54 percent iron-28 percent nickel-18 percent cobalt)-copper, Kovar-Constantan, nickel-Constantan, nickel-copper, nickel-Chromel, copper-Constantan, Inconel-Constantan.—BNF. 8267

7.7, 3.7.3

Developments in Spot Welding. *Metallurgia*, 49, No. 295, 218-219 (1954) May.

Thin, dissimilar metals representing opposite near-extremes in electrical conductivity are successfully welded in the assembly of a relay spring. The contact is of cadmium silver 0.025-inch thick and is spot welded to a nickel silver spring only 0.010-inch thick. Another good example of the electronically controlled spot welder's ability to weld dissimilar metals is the assembly of a stud contact. The brass stud is nickel-plated and to it is welded a 1/8-inch diameter 0.025-inch thick platinum contact.—INCO. 8178

7.7, 5.3.2

Cadmium for Plating Connectors. D.

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C. HUBBARD. *Elec. World*, **141**, 47-50 (1954) March 29.

The results of four years' research have shown cadmium and hot-flowed electro-tin plate to be the most suitable materials for plating connectors used in aluminum-to-copper connections. The characteristics of cadmium plating and the performance of various plating materials in numerous corrosion and physical tests are described in detail.—ZDA. 8070

7.7 **Lightweight Waveguides.** P. A. AKIN. Wright-Patterson Air Force Base. *Elec. Mfg.*, **53**, No. 3, 112-117 (1954) March.

Fabrication of stainless steel Type 302 waveguides is described. Stainless steel is commercially available in a lightweight form and suitable for plating forming and welding operations. Silver is preferred over copper as a coating on the stainless because of superior electrical conductivity and corrosion resistance. The silver plate is preceded by a nickel plate. Illustrations.—INCO. 7985

7.7 **The Behaviour of Metallic Contacts at Low Voltages in Adverse Environments.** ALAN FAIRWEATHER. *Proc. Inst. Elec. Engrs.*, Pt. 1, **100**, 174-182 (1953) July.

Behavior of a closed contact subjected to corrosion and closure processes for a corroded contact, both with and without "wipe." Theoretical basis for design and testing techniques. Diagrams.—MR. 8022

7.7, 7.2, 8.2.2

Pipe-Type Cable Corrosion Protection Practices in the Utilities Industry. FRANK KAHN, Chairman. First Interim Report of Technical Unit Committee T-4B on Corrosion of Cable Sheaths: Compiled by Task Group T-4B-4 on Protection of Pipe-Type Cables. *Corrosion*, **10**, No. 9, 299-313 (1954) September.

Data received in reply to a questionnaire is compiled on the actual field practices of utilities operating pipe-type cables. The data cover more than 90 percent of this type of cable in operation at the time the survey was made. The principal data are tabulated, giving reports by seventeen operators on field practices. The subjects covered include size and kind of pipe, coating materials, holiday testing, potential surveys, cathodic protection, coating resistance measurements, rates of coating resistance depreciation, bonding stray current measurements, shunts, surveys, voltages and magnitudes of cathodic protection currents and other information. 8214

7.7 **Corrosion of Heating Electrodes in Molten Chloride Baths.** H. R. COPSON (Inco.). Paper before Electrochem. Soc., Montreal, Oct. 26-30, 1952. *J. Electrochem. Soc.*, **100**, No. 6, 257-264 (1953) June.

Laboratory tests using Inconel electrodes and a sodium chloride, potassium chloride salt bath at 1500F showed pencilling to be an electrochemical phenomenon, controlled by a protective oxide film on the electrodes. Under conditions of film breakdown the electrodes dissolve during the anodic part of the a-c cycle. The metal ions formed plate back during the cathodic part of the cycle as a non-adherent powder which settles out. No pencilling occurred in fresh pure salt. In the presence of current the film damage in alkaline salt led to pencilling, which increased rapidly with current density. Pot composition had an effect on the rate of pencilling, particularly at

higher current densities; lowest rates were obtained in nickel pots. Three methods of preventing pencilling involved the use of rectifiers to remove alkalinity, the use of oxidizing agents to maintain a protective film on the electrodes and the use of the low current density. Tables, graphs and four references.—INCO. 7937

7.8 Wires and Cables (non-electrical)

7.8, 5.3.2

Influence of Coating Quality on the Corrosion Resistance of Galvanized Steel Wires. (In French). JEAN HERENGUEL. *Rev. met.*, **51**, No. 1, 36-44 (1954) Jan.

The presence of high amounts of iron does not seem to have any appreciable influence on the corrosion resistance, but it diminishes considerably the flexibility and adhesion of the coating. In general, the composition, as well as the uniformity of the coating layer are of much less importance than is its thickness (amount of zinc) in determining corrosion resistance, provided there has been no deformation prior to the onset of corrosion. The susceptibility of zinc coatings to plastic deformation depends on the total thickness, the iron content of the zinc layer, and the presence of an exterior layer of relatively low iron content.

Accelerated salt-fog tests showed that it is not possible to assess the quality of a zinc coating from the time of appearance of the first rust spot. For example, galvanized wires which showed some rust spots after two weeks were still in essentially the same condition at the end of fifteen months. Nevertheless, if the coating is mediocre, rust spots appear very quickly. There was satisfactory agreement between the percentage of surface rusted at the end of a certain exposure time and the thickness (g/dm^2) of the coating. Loss of breaking strength (generally a significant criterion for corrosion resistance) was of little value in these tests.—PDA. 8185

7.8, 5.3.2

Australian Developments in Drawn-Galvanized Rope Wires. F. W. WELSHMAN AND C. JAMES. Paper before Australian Inst. Metals, Symp. on Theory and Practice of Wire Drawing, Univ. Melbourne, November 13, 1953. *Australasian Engr.*, 1954, 43-47, May 7.

Preparation and properties of galvanized wires for ropes are described and effect of various methods of coating illustrated. Difficulties of cold-working zinc-coated wire are reviewed. Properties of wire produced by the drawn-galvanized process show it to be superior, especially in bending-fatigue, to the finally-hot-dipped and bright-drawn wire. Tables, graphs.—INCO. 8236

7.10 Other

7.10, 1.2.5, 8.8.1

The Bursting Disc: A Modern Safety Device. J. M. PIRIE. *Chem. Age*, **69**, 957-960 (1953) Nov. 7.

Discs may be mounted in openings of ample size are not unduly heavy or expensive and can be made from suitable metals to resist almost any corrosive condition and for use at elevated temperatures; typical applications. Precision made certified discs are available.—BNF. 8040

7.10, 8.4.2, 1.6

Application of Automatic Ignition Systems to Commercial Gas Cooking Equipment. Am. Gas Assoc. Labs. Res. Bulletin No. 65, June, 1952, 72 pp.

Results of studies of commercial gas appliance ignition problems and of factors involved in the application of automatic ignition systems to such equipment, followed with experimental work to obtain data and develop information on automatic ignition systems with thermocouple elements when applied to commercial gas cooking equipment and subjected to operating temperature conditions considered representative of those encountered in the field. It appears that pilot burners made of low nickel content stainless steel would be more resistant to outage if used in territories where gas is free of unsaturated hydrocarbons or where cracking of the gas can be prevented by adequate protection from heat. There is a thermocouple element on the market which has a stainless steel shield covering the cold junction and part of the copper lead which helps protect them from elevated temperatures. Reference is made to platinum, iron, brass, copper, aluminum and chromel alumel and iron-Constantan thermocouples. Illustrations, 27 references.—INCO. 7939

7.10, 4.2.3

How Can We Stop Stack Corrosion? *Power*, **98**, No. 9, 134, 136, 200 (1954) Sept.

A 15-yr.-old stack collapsed during removal for replacement. Checks showed the $\frac{3}{4}$ -inch mild steel plates had thinned to $\frac{1}{16}$ inch. Question concerned economy of removing the stack or leaving it in service until its own weight caused it to fall. Suggestions to eliminate or reduce corrosion include a steel stack of low chromium-copper alloy steel with a coating or lining inside the stack, an insulating lining, painting with a suitable temperature resistant paint, lining with gunite or another refractory, lining with magnesite, and use of a protective metal, such as zinc, lead, copper, nickel or tin or applying a protective paint. It was considered too hazardous to plant and personnel to wait until the stack fell.—INCO. 8393

7.10, 6.2.3

Steel Cartridge Cases. W. N. KING. Federal Cartridge Corp. *Ordinance*, **39**, No. 205, 49-52, (1954) July-August.

Fabrication of .45 caliber cartridge cases from low-carbon steel at Twin Cities Arsenal. Annealing, drawing, heading, trimming and plating procedures are discussed. Phosphate film and soap coating are used as drawing aids. Standard protective finish is zinc, electrically plated on the case, followed by a supplementary chromate treatment to give added rust resistance. To prevent splitting of cases when fired, the finished cases are stress-relief annealed.—INCO. 8266

7.10, 6.2.5

Corrosive Conditions Encountered by Edge Cutlery. C. N. KINGTON. *Corrosion Technology*, **1**, No. 7, 226-228 (1954) Sept.

Use of plain carbon steel and 12-14 percent chromium stainless steel for edge cutlery is discussed in connection with corrosion resistance. Moisture, immersion for long periods in water containing salts and chlorine and chlorides

are to be avoided. Chemicals or treatments which strengthen or toughen the surface oxide film may increase corrosion resistance. Prompt cleaning of stainless cutlery as described will give the steel a fair chance and eliminate any possible corrosive conditions.—INCO. 8118

7.10, 6.3.10, 6.3.2

Nickel-Cadmium Battery. *Mech. Eng.*, 76, 174-176 (1954) Feb.

An easily maintained nickel-cadmium storage battery is described. It is claimed that the usual troubles due to shock, vibration, overcharging, reverse charging or short circuiting are not encountered. The battery uses an alkaline solution instead of acid and will operate under extremes of temperature as high as 165 degrees F and as low as -65 degrees F.—ZDA. 8190

7.10, 7.7

Power Line Leaps James River. H. W. FURLONG. *Eng. News-Record*, 152, No. 19, 32-33 (1954) May 13.

Transmission lines cross James River Bridge on steel tripod-designed towers. Tower foundations consist of three steel H piles in tripod formation. Piles are capped with a concrete mat above low water level. Steel cylinders filled with reinforced concrete and treated bitumastic paint were placed around top of each steel pile to protect against sea water corrosion. Steel piles connected by circumferential stainless cables protect towers in deep water from shipping. Towers in shallower water are protected by wood piles connected by stranded stainless cables. Illustrations and diagram of construction features.—INCO. 8097

7.10, 8.9.3, 4.5.1, 2.2.6

Electrical Measurements in the Selection of Bolt Materials for Service Underground. W. J. SCHWEDTKE. *Corrosion*, 10, No. 10, 355-363 (1954) Oct.; *J. Research National Bureau of Standards*, 52, No. 5, 265-274 (1954) May.

Electrical measurements made in the laboratory are useful in generally predicting the relative behavior of bolt materials underground as pertaining to the corrosive effect of the soil. Some arbitrarily chosen low-alloy ferrous materials are shown to be superior to plain cast iron or steel commonly used for the fabrication of bolts. The effect of exposure on the potentials of cast iron and galvanized iron as components of galvanic couples is described. 8390

8. INDUSTRIES

8.1 Group 1

8.1.2, 6.3.6

New Copper Roofs for U. S. Naval Academy. L. E. GICHNER. *Sheet Metal Worker*, 45, Nos. 8 & 9; 84-85, 125; 92-94 (1954) May, June.

Discussion of improper method of installation of original roof which caused leakage. Each sheet of 20 oz. soft copper was firmly anchored with brass screws and horizontal seams of the pans between pans were soldered, seriously restricting expansion and contraction. 100,000 lb. of 16-oz. copper was used on the new roofs. Felt paper and red building paper to act as a cushion, cleating of the copper pans, and liberal seam allowances are some of the features of installation that permit expansion and contraction. Illustrations.—INCO. 8059

8.1.2, 6.4.2

"Alu Palast"—Exit. *Light Metals* (England), 17, No. 190, 2 (1954) January.

The "Alu Palast" a theatre constructed of aluminum during the period of the German trade fair at Hanover has now been scrapped. The principal aluminum alloy employed was of the group designed for aircraft, containing copper and magnesium. Condensation, arising from the high humidity occasioned in the building by the continued presence of large numbers of people, appears to have caused initial heavy corrosion on the interior surface of the building.—ALL. 8137

8.1.4

Sewage Treatment Plant Equipment. F. L. FLOOD. *Water & Sewage Works*, Part 2, 101, No. 5, R234-R235+ (1954) May.

Sewage treatment equipment is discussed in detail. Sprockets of the grit chambers and settling units are of alloy cast iron with 1-1.25% nickel and 0.45-0.65% chromium. Chains used in the settling units are fabricated of malleable iron such as Supermal, Promal of Z-metal. Sludge cake take-off plate used in vacuum filtration has a replaceable cutting edge of 18% chromium-8% nickel steel alloy. Some rabble arms on the combustion hearths are of 25% chromium-12% nickel, others of 12% chromium-12% nickel or Nercaloy. Drying towers were initially lined with stainless steel but were replaced with a ceramic material. 16 references.—INCO. 8065

8.3 Group 3

8.3.3

Metals and the Dairy. G. H. BOTHAM. *J. Soc. Dairy Technol.* 6, 179-187 (1953); *Chem. Abs.*, 48, 93 (1954) January 10.

Weight losses in corrosion tests with mineral acids, lactic acid or ferric chloride were much less from tin-nickel coatings than from pure tin or nickel coatings. Chromized titanium steel was completely resistant to boiling 1% lactic acid containing 1% sodium chloride and to 1% nitric acid, but was less resistant to boiling 2% phosphoric acid than was 18/8 stainless steel. Weight losses in tests with these acids and other stainless-steel alloys are given.—INCO. 8328

8.4 Group 4

8.4.3

Research Pertaining to the Use of Chemicals in Petroleum Production. J. WADE WATKINS, H. N. DUNNING, AND C. J. WILHELM. *Producer's Monthly*, 17, 14-21, 24 (1953) June.

Discusses the research studies on drilling muds, well shooting, demulsification, corrosion, water conditioning, surface-active additives, water tracers and selective plugging. Graphs, photographs, diagrams, tables.—BTR. 7950

8.4.3, 6.2.5, 1.2.2

Performance of Stainless Steels in Petroleum Refinery Service. 1953, 44 pp. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania. Gratis.

Because of the combined effects of obsolescence, high temperatures, pressures and highly corrosive agents used it is estimated present day refinery equipment

must be replaced every five years at a cost of about eight cents per day per barrels of capacity. This pamphlet collects from a large number of sources corrosion data based on actual refinery experience. The subjects covered in the booklet, which is in color, fully illustrated, with many tables and graphs include: general corrosion, which covers atmospheric, wet chemical and elevated temperatures; intergranular corrosion, which covers carbide precipitation, attack by molten metals and sulfur attack.

Strength information is divided into short-time tensile, long-time creep and rupture properties; properties at atmospheric temperatures after exposure at elevated temperatures. 7959

8.4.5

The Homogeneous Reactor Experiment. S. E. BEALL AND C. E. WINTERS. *Oak Ridge Nat. Lab. Chem. Eng. Progress*, 50, No. 5, 256-262 (1954) May.

Homogeneous Reactor Experiment—a nuclear pilot plant for the production of electricity with an aqueous solution of uranium as fuel—was operated by the Oak Ridge Laboratory over a two-year period. In the reactor fuel system, nuclear energy was released in the reactor core, which was a stainless steel sphere 18 inches in diameter. As to chemical stability and corrosion, the fuel and its 347 stainless steel container were sufficiently rugged to withstand a protracted test period. More will be known now that the machine is being disassembled for examination. Gross corrosion rate was followed by periodic analysis for nickel. Graphs, diagrams and tables.—INCO. 8005

8.4.5, 7.2, 7.3

Piping, Pumps and Valves for High Pressure Water Reactor Systems. A. AMOROSI. Argonne Nat. Lab. Paper before Am. Power Conf., Chicago, 1954. *Heating, Piping, Air Conditioning*, 26, No. 5, 140-144 (1954) May.

Radioactivity problems of high pressure, water cooled nuclear plants and their effects on selection of materials and design of components are discussed. Extensive tests were made in high temperature water to determine the relative corrosion resistance of materials of interest. Table shows the relative corrosion resistance of various metals including aluminum, chromium, cobalt, copper, copper-nickel, nickel and nickel alloys, steels and stainless steels and others in degassed water at 200, 400 and at 600F. Stainless steel shows no sign of intergranular attack in pure water. Most of the materials tested showed increased corrosion rates in oxygenated water, up to some concentration of oxygen, then a decreasing corrosion rate. Graphs.—INCO. 8011

8.4.2

25 Years of Progress in Gas Purification. N. C. UPDEGRAFF AND R. M. REED. Girdler Company. *Petroleum Engr.*, 26, No. 10, C57-C58, C60-C63 (1954) Sept.

Gerbitol process, employing amine solutions to remove carbon dioxide and hydrogen sulfide from various industrial gases, is discussed. Corrosion of equipment has been a serious problem in some plants. Use of Gunite concrete linings plus the use of stoneware packing has proved successful in overcoming corrosion in reactivators. Aqueous amine solutions were shown to be less corrosive than glycol-amine solutions. Reboilers have corroded in the same plants in which severe reactivator corrosion has occurred. Process corro-

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sion has appeared to be due to specific conditions of temperature and concentrations of hydrogen sulfide, carbon dioxide and amine occurring in certain parts of the equipment. Flow diagram.—INCO. 8239

8.4.2, 8.4.3

Hydrogen Sulfide Removal for \$76 Per Million Feet. R. A. FEAGAN, H. L. LAWLER AND M. H. RAHMES. Stanolind Oil & Gas Co. Paper before NGAA, Dallas, April 21-23, 1954. *Oil Gas J.*, 52, No. 51, 280+ (1954) April 26.

Tentative conclusions one company has reached based on 4-5 years' experience operating five hydrogen sulfide-removal units with aqueous monoethanolamine are summarized. Corrosion was experienced primarily in the reactivator reboilers, reactivators, solution pumps, heat exchangers and related piping. Reboiler life has ranged from two months to more than one year with the improvement credited to changes in design and operating conditions. Carbon steel reboilers in other plants have lasted several years. One carbon steel reactivator tower was completely replaced, two others repaired and modified after bubble-cap trays were corroded away. Number of heat-exchanger bundles were repaired or replaced. Recommendations for controlling corrosion are listed. Nine references.—INCO. 8221

8.4.2, 8.4.3

Experience with Amine Units. R. A. FEAGAN, H. L. LAWLER AND M. H. RAHMES. *Petroleum Refiner*, 33, No. 6, 167-168 (1954) June.

Design and operating hints to cut corrosion and amine losses in amine gas treating plants. Some recommendations to reduce corrosion are avoiding use of dissimilar metals, redistilling amine and providing a suitable amine reclaimer, providing effective filter to remove iron sulfide corrosion products in the amine systems, and stress-relieving major equipment. 9 references.—INCO. 8200

8.4.3

Combating Corrosion Offshore. FRANK DIAL. Pure Oil Co. *World Oil*, 138, No. 7, 206, 208, 210, 212 (1954) June.

A report assembling and evaluating the various factors of corrosion prevention on offshore drilling and producing structures as experienced by operators to date. An outline for the zones of corrosion attack is presented. Maintenance, design for maintenance and initial protection are factors considered in planning corrosion protection program. A chart lists protective barriers, their advantages and disadvantages and zones to which they are applicable. Monel sheathing is included in the chart.—INCO. 8083

8.4.3

Production Highlights Along Gulf Coast. J. E. KASTROP. *World Oil*, 138, No. 7, 122, 124, 126, 128, 133-134, 136, 138 (1954) June.

Four broad types of oil field corrosion in the Gulf Coast and methods of protection are considered. Gas-condensate corrosion, due to formation of organic acid and carbon dioxide in the water condensing out of the gas, was mitigated by plastic coatings, organic treating compounds and neutralizing agents. Nickel alloy metals proved not completely satisfactory. Sweet oil well corrosion, which occurs when water production is relatively high, was controlled

by plastic coatings and organic inhibitors. Water independent high-pressure corrosion, which is caused by formation of sulfuric acid by hydrolysis, has no effective control as yet. Sour crude corrosion caused by hydrogen sulfide is mitigated by formaldehyde treatment and organic inhibitors. Surface corrosion problems and practices such as coatings and cathodic protection are discussed.—INCO. 8155

8.4.3

Offshore Drilling Platforms—Structural Details, Wave Forces and Safety Precautions. C. E. KOLONZEY. Paper before Soc. Naval Architects & Marine Engrs., New Orleans, April 23, 1954. *Mariner*, 1; Nos. 5 & 6; 24-26, 54-56; 28-29, 38-39, 42-43 (1954) May, June.

Platforms are of timber, steel and concrete. A feature of one of the platforms described is that wall thickness of column legs and bracing is 3/4-inch thick for corrosion allowance.—INCO. 8144

8.4.3, 1.6, 2.2.1

Permian Basin Fifth Biennial Corrosion Tour. 61 pp., 1954. Permian Basin Section, National Association of Corrosion Engineers. Available from John A. Knox, The Western Company, Midland, Texas.

This publication is a narrative of the September 30, October 1 and 2, 1953, 5th Biennial Corrosion Tour sponsored by NACE's Permian Basin Section. It includes descriptions of the numerous exhibits of oil well production and storage equipment in and around Midland, Texas. The equipment is described, the type of protection itemized and the degree of change from the last inspection is indicated. In some instances registrants had the opportunity to see the progress of corrosion or the advantage of corrosion control measures since 1951 on the same equipment.

Equipment inspected included asbestos cement, cement lined, inhibited, plastic coated and plastic pipe lines; refinery equipment, tanks with aluminum decks, ammonia treated, coal tar and plastic coated, concrete bottomed, galvanized, nickel plated bottomed and plastic bottomed tanks, plastic coated treaters, salt water disposal and water flood systems and the effect on wells of alloys, cathodic protection, inhibitors and plastic coating. 8123

8.4.3, 3.2.2

Metals in Oil Refining. I. H. THOMAS. Paper before Midland Metallurgical Soc., March 4, 1954. *J. Birmingham Met. Soc.*, 34, 51-70 (1954) June.

Covers brittle fracture in steels, electrochemical corrosion, corrosion in refinery processes, graphitization of cast iron (use of Ni-Resist), hydrogen blistering of steel at low temperatures, stress corrosion cracking, high temperature problems (graphitization of steel, sulfur attack, naphthenic acid attack, carburization, hydrogen attack, creep-resisting steels), and low temperature construction materials (nickel steels and austenitic steels).—INCO. 8249

8.4.3, 4.2.3

Conditioning Engine Exhaust Gas for Injection Into Oil Reservoirs. J. N. BRESTON, R. C. NEAL, H. J. BOHNE AND J. C. WATERMAN. *Producers Monthly*, 17, 72-82 (1953) April.

Presents a comprehensive analysis of the corrosivity of combustion gases and the possible methods of preventing or

eliminating such properties. Diagrams, graphs, photographs, tables. 12 references.—BTR. 8318

8.4.3, 5.8.2

Corrosion Control in Gas Lift Wells. II. Evaluation of Inhibitors. D. A. SCHOCK AND J. D. SUDBURY. *Corrosion*, 10, No. 9, 289-294 (1954) Sept.

Conditions in gas lift wells producing appreciable proportions of water are reviewed. Principal corrodent is reported to be carbon dioxide and certain peculiarities of gas lift wells are enumerated. Because of the importance of the ionic composition and chemical content of produced waters, especially those of Gulf Coast wells, the scaling problem associated with these wells is an important consideration in devising inhibitive practices.

Because a current statistical analysis indicates about 4000 Gulf Coast gas lift wells probably are already corrosive and because it is expected that 16,000 ultimately will be corrosive the authors point out a potential corrosion damage of as much as \$16,000,000 annually.

Chemicals used to inhibit corrosion in these wells must have the faculty of penetrating the column of oil and water standing in the well. Laboratory experiments using a model gas lift well and actual produced fluids are described. Some currently available inhibitors have the disadvantage of forming insoluble salts with the calcium and magnesium ions and thus their use is precluded. Furthermore these compounds have not proved stable at reservoir temperatures.

Arsenical inhibitors consisting of solutions of sodium arsenite and sodium polyphosphate which proved in tests to be an adequate inhibitor, subsequently were the cause of such difficulties, their use was abandoned generally. Continued tests in two wells indicated they could be used when properly diluted if treatment was continuous and batch fed. Arsenic precipitation was seen as a possible bad effect but reversion of polyphosphates was not encountered. Further there was some suspicion arsenic from these inhibitors resulted in the poisoning of the catalyst in a catalytic cracker. Subsequently it was learned the standard electrical desalting process effectively removes the arsenic.

Investigations of organic polar compounds weighed with ethylene glycol resulted in the Continental Oil Company developing its own inhibitors. One of these is being tested in a 7600-foot well. 8228

8.4.3, 5.8.2

High-Pressure-Gas Production in Louisiana. T. E. GRIFFITH AND C. O. MILLER. Paper before NGAA, Dallas, April 21, 1954. *Oil Gas J.*, 52, No. 51, 227-230 (1954) April 26.

Deeper drilling and resulting higher-pressure gas discoveries bring additional problems, one of them corrosion. Pitting has been measured as much as 1/32-inch deep in a 5-month period. Corrosion control equipment was installed to inject chemicals down the tubing to inhibit corrosion of the tubing and protect christmas tree and surface facilities.—INCO. 8107

8.4.3, 5.8.2

Survey of Corrosion Control in California Pumping Wells. FRANK E. DAVIE AND PRESTON W. HILL. *Corrosion*, 10, No. 8, 248-251 (1954) August.

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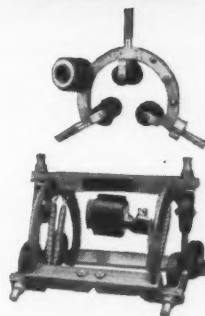
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corrosion control in a representative group of California wells. The data were furnished by the members of TP-1A Committee on Corrosion of Oil & Gas Well Equipment, California and were collected and correlated using hand-sort punch cards. Information obtained from 17 fields and 14 companies covers some 350 wells on which complete data were available. The wells vary from 1000 to 8000 feet in pump depth and produce up to 1000 b/d gross.

The survey indicates that the use of various inhibitors has so far resulted in an average of 50 percent reduction in pulling jobs. Material replacements are reduced by an even greater percentage.

8079

8.4.3, 7.6.5, 7.4.2, 6.6.11

Redwood Steam Treaters Save Important Money by Ending Scale-Removal Costs. R. W. H.... Stanolind Oil & Gas Co. *Oil Gas J.*, 53, No. 21, 69-70 (1954) September 27.

Redwood steam treaters have replaced conventional steel treaters in fields where corrosion and scaling are severe. In three years there was no expense attributable to corrosion and scaling in 13 redwood steam treaters, whereas cost of corrosion and scale formation averaged \$74 per month for each steel installation. Both Monel U-tube-type and cast iron coil-type heat exchangers are used in the redwood vessel. Illustrations.—INCO.

8124

8.4.5, 4.7

Materials Problems in Nuclear Power Reactors. H. H. HAUSNER, Sylvania Electric Products, Inc. *Materials & Methods*, 40, No. 1, 84-86 (1954) July.

Problems encountered in designing reactors are discussed: mechanical behavior at elevated temperatures, corrosion behavior, heat transfer and thermal conduction, thermal shock behavior of metal-nonmetal combinations and radiation damage. Corrosion in a nuclear reactor is connected with the type, temperature and pressure of the coolant and occurs between fuel cladding and coolant, between fuel metal and coolant due to imperfect cladding, between coolant and coolant transportation systems and between coolant and heat exchanger. Investigations on corrosion resistance of various metals and alloys in liquid sodium were made under static and dynamic conditions. Pure iron, ferritic stainless steel (12-27 percent chromium) and austenitic stainless steel (18-8 and 25-20 chromium-nickel) show excellent corrosion resistance up to high temperatures, whereas low-chromium steels and mild carbon steels show only poor corrosion resistance above 100 degrees F. Zirconium does not corrode in liquid sodium up to 1100 degrees F, but shows only limited resistance at 1470 degrees F. Fifteen references.—INCO.

8117

8.4.5, 3.4.10

How Radiation Affects Important Materials. S. S. JONES. *Gen. Elec. Rev.*, 57, No. 4, 6-11 (1954) July.

Various materials were tested for radiation damage, using Co^{60} as the gamma-emitting isotope. Test method is described. Gamma radiation has no significant effect on metals other than heating effects, but gamma rays indirectly influence corrosion of metals. Surface films on metals may be damaged by direct radiation or indirectly by corrosive chemicals produced by irradiation of the environment. Glass, polymers,

cellulose and its derivatives, and rubbers are affected by radiation. Polytetrafluoroethylene is noted for its outstanding resistance to corrosives, but under gamma radiation it loses its structural strength, becomes brittle, and falls apart. Polystyrene and aniline-formaldehyde polymer are among materials most resistant to radiation damage.—INCO.

8215

8.4.5, 8.8.1

A Continuously Separating Breeder Blanket Using ThF_4 . E. T. MILES, R. H. WISWALL, R. J. HEUS AND L. P. HATCH. *Nucleonics*, 12, No. 7, 26-29 (1954) July.

Development of a breeding blanket that produces U^{235} from thorium by neutron capture and that incorporates the chemical processing necessary to separate U^{235} from thorium. In-pile reaction vessel is 1 inch nickel tube extending into reactor to point where neutrons flux is about 1×10^{12} . Fluorine-helium mixture passes over ThF_4 sphere, leaves reactor through small-bore nickel tubing heated uniformly to 200 degrees C to prevent adsorption of UF_6 . Regeneration cycle—hydrolysis of ThF_4 to oxide and reconversion to fluoride—produces an unprecedented corrosion problem. Blanket container would have to withstand exposure to alternate atmospheres of fluoride and steam-hydrogen fluoride mixtures. Cycle regenerating ThF_4 destroys the fluoride film that protects metals from fluorine attack. A few metals form fluorides that are resistant to hydrolysis and are not attacked by hydrogen fluoride-water mixtures that hydrolyze ThF_4 . It would be possible to develop a material using magnesium fluoride in ceramic form or as a coating on a metal. Illustrations.—INCO.

8213

8.5 Group 5

8.5.3

Chlorine Dioxide Bleaching. W. H. RAPSON. Paper before Am. Pulp & Paper Mill Supts. Assoc., Montreal, June 21-23, 1954. *Paper Ind.*, 36, No. 6, 575-578 (1954) Sept.

Corrosion problem in chlorine dioxide plant is overcome by using tile-lined towers, painted with a furane resin cement, and plastic-lined or ceramic piping. Chief problem is with the mixer. It has a relatively long life if made of Hastelloy C type alloys, but these alloys are expensive. Mixers made from 316 stainless with very low carbon are being used, but they have a short life, usually between one and two years. 8 references.—INCO.

8310

8.5.3

Ammonia-Base Sulfite Pulping—A Staff-Industry Collaborative Report. W. Q. HULL, B. C. SMITH, J. H. HULL AND W. F. HOLZER. Crown Zellerbach Corp. *Ind. & Eng. Chem.*, 46, No. 8, 1546-1557 (1954) August.

Detailed description of ammonia pulping process and equipment at the plant in Lebanon, Oregon. Ammonia is substituted for conventional calcium to combine with sulfur during the burning operation. In the evaporation system, channel switching of liquid and steam plates is employed for scale control (enough calcium from wood ash warrants this although ammonia base eliminates scale-forming materials from cooking chemicals) and all plate materials coming in contact with the liquor or vapor are of

Type 316 ELC or 317 ELC alloy stainless steel. Ammonium sulfite-bisulfite circulates through wood stove absorption towers and is pumped through a stainless steel heat exchanger. Mixture of ammonium lignin sulfonates and sugars constitutes a valuable by-product made from liquor concentrate. In making these products, concentrated stock is pumped through a stainless steel, high pressure, triplex pump which discharges the liquor into an all stainless steel (Types 304 and 316) spray dryer. Flow sheets for the entire process and a table of North American mills using ammonia-base pulping are included. 18 references.—INCO.

8135

8.5.3, 4.3.7

Bleaching with Peroxides and the Use of Peroxide in Waste Paper Recovery. *Paper Ind.*, 36, No. 6, 584-588, 596 (1954) Sept.

Undissolved sodium peroxide can be handled in dry iron or steel equipment, but long exposure to humid atmospheres must be avoided. Stainless steel is preferred for handling sodium peroxide solutions. Concentrated hydrogen peroxide solutions can be stored in containers of 99.6 percent aluminum which has been cleaned and pickled. Pipelines for conveying hydrogen peroxide can be of commercial 3S aluminum piping. Where pumps are used, parts which come in contact with hydrogen peroxide must be stainless steel of 304, 347, or 316 types. Valves of similar stainless steel can be used for control. Tables and diagrams.—INCO.

8289

8.7 Group 7

8.7.1, 5.4.5

Plastic Protection for Printing Blocks. *Ind. Finishing*, 6, No. 67, 423-424 (1954) January.

Printers' blocks, plates, electros, stereotypes, etc. have delicate surfaces liable to damage during the course of processing, handling and storage. The metals used for them such as zinc, copper and lead, can be easily etched and engraved and are therefore highly sensitive to the effects of air, oxidation and acid fumes. For the protection of block surfaces, Corrosion Ltd. have developed a plastic coating that is applied cold by brushing, dries rapidly and is easily removed.—ZDA.

8148

8.7.4

Fabricating Stainless Photographic Equipment. *Sheet Metal Worker*, 45, No. 7, 62-63, 117-118 (1954) April.

Type 316 stainless, with molybdenum added to give extra protection against hypo, is used in the fabrication of sinks and photographic equipment. The exhaust fan housing of the dehydrator is of Type 430 since this section does not come in contact with hypo.—INCO.

8288

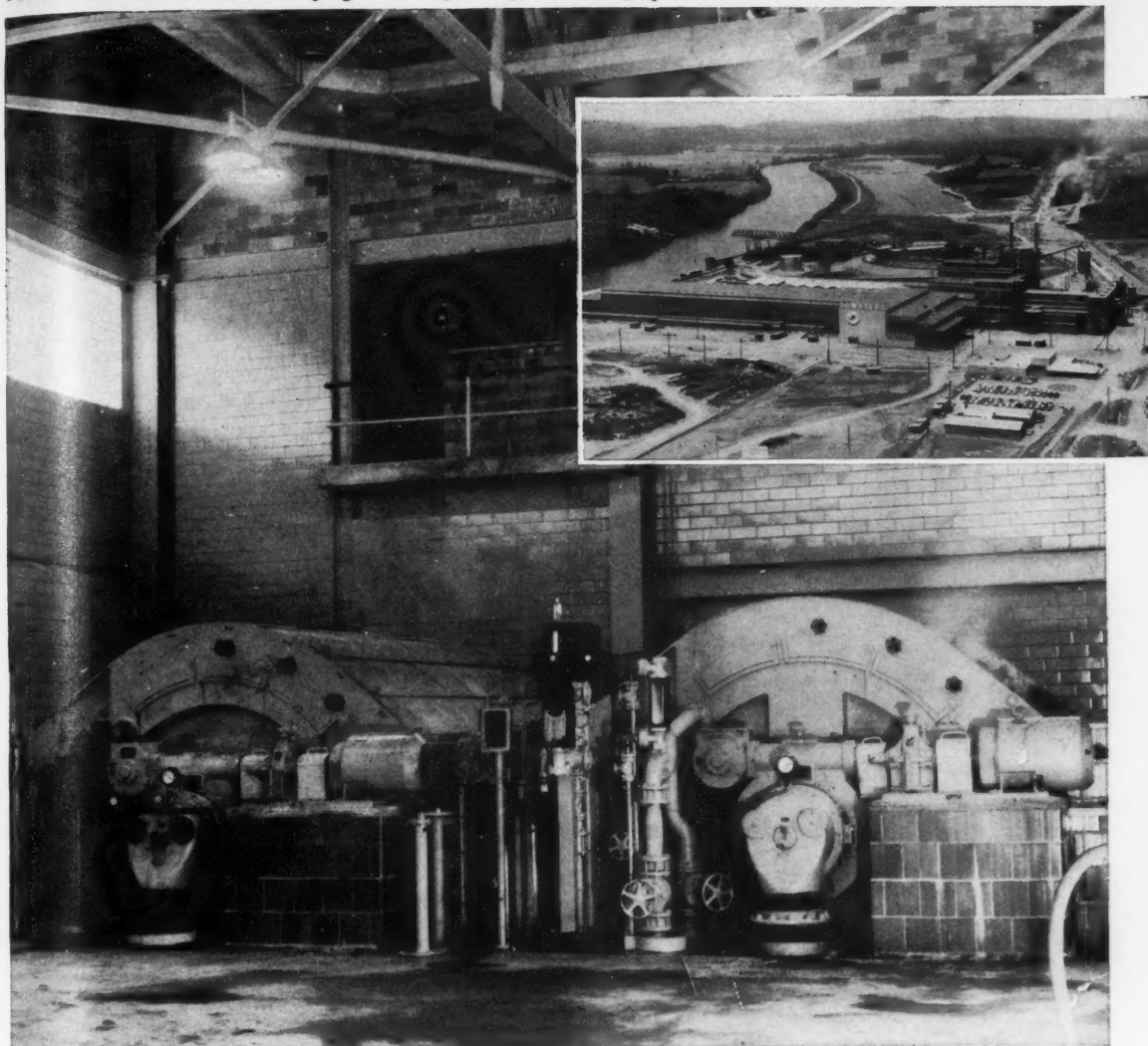
8.8 Group 8

8.8.1

Epoxidation of Methyl Oleate with Hydrogen Peroxide. W. R. SCHMITZ AND J. G. WALLACE. Paper before Am. Oil Chemists' Soc., 27th Ann. Mtg., Chicago, Nov. 4-6, 1953. *J. Am. Oil Chemists' Soc.*, 31, No. 9, 363-365 (1954) September.

An important aspect of commercial epoxidation is the type of material required for equipment. Preliminary tests indicate that several of the stainless

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steels are quite satisfactory for corrosion resistance and effect on reaction. Duplicate coupons of types 304, 316, 321, 329, and 430 and one of 2S aluminum were suspended half-way in a solution containing glacial acetic acid, sulfuric acid, and hydrogen peroxide at 40-45 degrees C. After 3 hrs., sodium acetate trihydrate was added to neutralize the sulfuric acid catalyst; then methyl oleate was added slowly. Epoxidation was conducted at 45 degrees C. 5 hours were required for each cycle of peracid formation and epoxidation. The metal coupons were weighed after each exposure to determine loss of weight, then exposed again to peracid formation and to epoxidation reaction. Analyses of products from each experiment showed that metals exerted no adverse effect on yield of epoxide. Mild steel (1020) was exposed separately to peracid formation, but coupons were attacked severely (4 percent loss in weight) and caused rapid and exothermic decomposition of hydrogen peroxide and peracetic acid. The 2S Al coupon showed considerable etching and staining while none of the stainless steel coupons showed any visible change over the surface area. The corrosion rates, calculated on a continuous basis, are given in a table. 12 references. —INCO. 8257

8.8.1

Development of Processes for Production of Fused Tri-Calcium Phosphate. J. C. BROSHIER AND T. P. HIGNETT. Tennessee Valley Authority Chem. Eng. Rept. No. 7, 1953, 85-86.

Cooling pipes protecting furnace walls from damage by heat, were subjected to corrosion by fluorine and sulfur compounds. Pipes of mild steel and AISI Types 304 and 316 stainless steels lasted only a few weeks. Copper, Monel and brass were tested and found to have low corrosion rates. Monel was also used on the inner surface of a newer hearth section designed to avoid the difficulties mentioned above.—INCO. 8332

8.8.1, 4.3.3

Interaction of Alkali Metals and Liquid Ammonia: Catalysis by Metals and Alloys. G. W. WATT, G. D. BARNETT AND L. VASKA. *Ind. & Eng. Chem.*, 46, No. 5, 1022-1024 (1954) May.

Metals commonly used for construction of process equipment catalyze the reaction between liquid ammonia and alkali metals to form hydrogen and the corresponding amides. Use of such solutions would be more attractive if otherwise suitable non-catalytic metals or alloys could be found and the use of glass-lined equipment avoided. Rates of reaction between potassium and liquid ammonia and its boiling point were measured using metals, such as tantalum, titanium, nickel and platinum, and alloys, such as stainless steels, Hastelloy, and Monel, as catalysts. Pure metals were the least active catalysts except for nickel. Alclad aluminum exhibited a low level of catalytic activity and vessels fabricated with this alloy and bearing a thin oxide film would probably be satisfactory containers for solutions of metals in ammonia. Graphs, tables and 11 references.—INCO. 8360

8.8.1, 4.3.4, 4.3.5

Recent Chemistry of Fluorine and Its Compounds. G. M. DYSON. *Chem. Products*, 17, 133-138 (1954) April.

Recognition that carbon electrodes

and copper or nickel cells could replace noble-metal assembly of Moissan and lead to development of modern process of fluorine production in which electrolysis occurs at elevated temperature, using cells of mild steel with sheet steel cathodes and carbon anodes separated by an 8-mesh Monel metal screen. Reference is made to use of cobalt trifluoride or difluoride in organic fluorination reactions instead of the use of free fluorine. Nickel moderately non-reactive to chlorine trifluoride becomes surface-coated, as also does mild steel. Nickel reactors are used in production of this material and steel cylinders used for storage. Chlorine trifluoride-hydrogen mixture is used in cutting and welding of copper.—INCO. 8217

8.8.1, 4.6.2

Corrosion Problems in Steam-Jet Vacuum Equipment. D. H. JACKSON. Croll-Reynolds Co., Inc., Paper before AIChE, French Lick, Ind., Mtg. *Chem. Eng. Progress*, 49, No. 2, 102-104 (1953) February.

Steam-operated vacuum ejectors which are more vulnerable to corrosion than other items of plant equipment are discussed. Materials used in ejectors are: hard rubber, Havg, Karbate, porcelain, Pyrex, stoneware, bronzes, chromium-plated cast iron, Duriron, Hastelloy alloys A, B and C, Ilium, tantalum, beryllium-copper, higher stainless steels in the metal field, Teflon and Synthane. Carbon is still the most reliable material for some applications. Impurities in raw materials, intermediate products or products of reaction in chemical process can accelerate corrosion or retard it. Photograph and diagrams.—INCO. 8199

8.8.1, 7.2

Valuable Intermediate: Ketene. K. A. KOBE. *Petro. Ref.*, 33, No. 8, 143-145 (1954) August.

Petrochemical process for production from isopropanol of ketene, an intermediate of acetic anhydride and acetate ester production, is described. In decomposing acetone by pyrolysis, it was found that undesirable reactions catalyzed by iron and nickel salts deposited large amounts of carbon in the pyrolysis tubes. 18-8 was satisfactory for the pyrolysis tube if treated so as to form a carbide film to prevent contact of metal with acetone. An 18-8-1 Ti stainless steel tube could be used if treated with a sulfur compound. Pyrolysis tubes of 25-20 are used at Courtalds, Ltd. and small amounts of carbon disulfide are added to the acetone to prevent carbon deposits. Flow-sheets, 20 references.—INCO. 8127

8.8.3, 1.6, 5.3.4

Handbook of Industrial Electroplating. E. A. OLLARD AND E. B. SMITH. Book. Second revised edition, 1954, 366 pp. Published for Metal Industry by Iliffe & Sons, Ltd., London.

A revised and enlarged version of the 1947 edition. This book is essentially for the practical man; it gives much useful information regarding solutions, equipment, etc., and methods of choice, installation and control. There are several new sections giving guides to effluent control, water treatment, safety precautions, plating on aluminum, magnesium and stainless steel, and plating shop costing and estimating. The list of tables has been extended to include sta-

bility of wetting agents, areas of B.A. screws, and composition of various aluminum alloys and the protective and decorative value of the anodic film. This last table should be very useful to anodizers.—BNF. 8345

8.8.3, 5.4.8

The use of Unplasticised Polyvinyl Chloride in Electroplating Plants. L. N. THOMAS. *Plating*, 41, No. 3, 269-274 (1954) March.

Corrosion resistance to over 250 chemicals; properties compared with polyethylene and polyvinylidene chloride; applications.—BNF. 8250

8.8.5, 8.7.2

Factors Influencing the Rusting of Precision Steel Parts During Manufacturing Process (In Russian). V. V. SKORCHELLETTI AND V. E. PISKORSKI. *J. Applied Chem. (USSR)* (*Zhurnal Prikladnoi Khimii*), 26, No. 7, 730-735 (1953) July.

Influence of relative humidity, temperature and contact with air containing sulfur dioxide on rate of rust spot generation was demonstrated by laboratory experiments. Graphs.—BTR. 8263

8.8.6, 8.3.5

Corrosion and Tablet Machinery. K. A. MITCHELL. *Corrosion Technology*, 1, No. 5, 161-162 (1954) July.

In the pharmaceuticals and confectionery industries where tablet-making machines are used, corrosion prevention is essential to ensure purity of the products. Tablet machines are of stainless steels with some Monel and nickel-silver feed shoes being used. Die table is covered by plastic plates. When ammonium chloride is used, special punch holders tipped with Stellite are employed, with dies and guide brushes also of Stellite. For a large number of pharmaceutical tablets, chromium-plated punches and dies are in use. Where the material is both corrosive and abrasive, tungsten carbide insert dies or Stellite dies are recommended.—INCO. 8171

8.9 Group 9

8.9.3, 5.2.1

A Billion Feet for Southern Natural. F. CHAPMAN. *Gas*, 30, No. 5, 117-118+ (1954) May.

New construction program of Southern Natural Gas Co. involves 4000 miles of pipeline in the ground with 22 compressor stations. Fundamental consideration throughout the laying operation in the south Louisiana system was provision for adequate corrosion protection. Of particular importance are those lines laid in brackish and salty waters of the lower delta and open Gulf. Cathodic protection engineers were called in during the planning stages to integrate the protection program with construction. Concrete coatings were used for protection of the enamel and wrap of the pipelines. For their protection in flotation canals, prefabricated anode strings totaling 400 lb. each were laid.—INCO. 8071

8.9.3, 5.2.3, 5.4.10

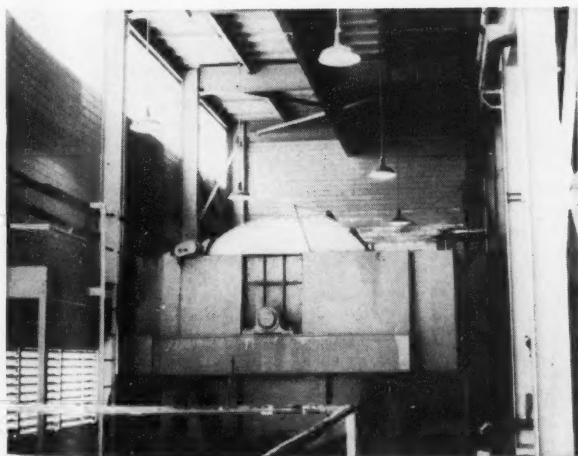
Experiences in Corrosion Control on a Products Pipeline. A. R. MURDISON. Paper before NACE, Feb. 1954. *Can. Chem. Processing*, 38, No. 8, 38, 40 (1954) July; *Can. Metals*, 17, No. 9, 16, 18 (1954) August.

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INDEX TO ADVERTISERS

Vol. 11	MAY, 1955	No. 5
		Page
Allen Cathodic Protection Co.		89
Amercoat Corporation.	Inside Back Cover	
American Chemical Paint Co.		92
Apex Smelting Company.		104
ARco Rubber Processors Division of Automotive Rubber Co., Inc.		97
Bakelite Company, A Division of Union Carbide and Carbon Corporation.		125
Bart Manufacturing Co.		74
Brance-Krachy Co., Inc.		129
Bute, James Co.		84
Carboline Company.		101
Carey, Philip Manufacturing Co., The		8
Cathodic Protection Service.		83
Coast Paint & Lacquer Co.		9
Columbia-Southern Chemical Corporation.		121
Corrosion Engineering Directory.		80
Corrosion Rectifying Co.		84
Dearborn Chemical Company.		69
Diamond Alkali Company.		81
Dow Chemical Company.		2
Dresser Manufacturing Div. Dresser Industries, Inc.		123
Duriron Company, Inc.	Inside Back Cover	
Hercules Powder Company.		127
Hill, Hubbell & Company, Div. of General Paint Corporation.		12
Humble Oil & Refining Company.		85
Insul-Mastic Corporation of America.		7
International Nickel Company, Inc.		1
International Paint Company, Inc.		86
Johns-Manville Sales Corporation.		10
Kellogg, M. W. Company, The.		14
Mayes Brothers, Inc.		6
National Association of Corrosion Engineers.	68, 82, 100, 116, 118	
National Carbon Company, Div. of Union Carbide & Carbon Corp.		117
Perma-Line Rubber Products Corporation.		95
Pipe Line Anode Corporation.		111
Pittsburgh Coke & Chemical Co.	Back Cover	
Plicoflex, Inc.		15
Polyken Products, Dept. of the Kendall Company.		87
Positions Wanted and Available.		73
Prufcoat Laboratories, Inc.		67
Reilly Tar & Chemical Corporation.		77
Resistoflex Corporation.		93
St. Joseph Lead Company.		109
Schramm Fiberglass Products, Inc.		66
Standard Magnesium Corporation.		115
Standard Pipeprotection, Inc.		99
Tapcoat Company, The.		72
Tnemec Company, Inc.		107
Tretolite Company.		130
Tube-Kote, Inc.		103
United Chromium, Inc.		11
United States Stoneware Co.		105
Wholesale Coke Supply Company.		76
William, T. D., Inc.		13
Wright Chemical Corporation.		79

Products pipe line is described and technical aspects of construction, such as sampling of soil resistivity, current requirements and number and location of rectifiers, and operation of the system are shown. Author believes that the best solution in the long run is a pipe with a good coating, followed by a systematic application of cathodic protection. Sarnia pipe is coated with a layer of coal tar enamel onto which is wrapped a fibreglass cheesecloth-like mat for tensile strength. Layer of felt paper is then applied over the coating as protection against damage while the pipe is being laid.—INCO. 8177

8.9.4, 2.3.2

Testing Tank Car Linings. J. ROBERT SPRAUL. *Corrosion*, 10, No. 8, 243-247 (1954) August.

The corrosion problems associated with tank car shipments are different than those encountered with stationary tank storage. Additional corrosive conditions are introduced because of the frequent loading and unloading of the car. Another factor is that the unloading of cars often is not complete and when it is not on the return trip serious corrosion can occur.

Conditions for the preferred use of protective coatings on the interior of the tank car are discussed along with life requirements. Corrosive factors such as dilution, aeration, liquid and vapor phase contact, presence of moisture, separation of phases and heat are discussed.

Long term tests would give the best estimate of the expected coating life, but frequently time requirements necessitate the use of short term accelerated studies. Various testing methods are discussed and an evaluation of their usefulness is given. In particular, a testing method incorporating partial immersion of a coated panel, aeration, humidity and heat is described and results given. Some data from actual tank car applications are presented. 8264

8.9.5, 1.2.2, 4.4.6

Control of Internal Corrosion of Tankers. W. B. JUPP AND C. J. LAMB. Paper before Am. Soc. Mech. Engrs., Ann. Nat. Petroleum-Mech. Eng. Conference, Houston, September, 1953. *J. Am. Soc. Naval Engrs.*, 66, No. 1, 152-165 (1954) February.

Corrosion in the cargo spaces of tankers depends upon the trade routes, the types of cargo carried and the frequency of ballasting and cleaning tanks. Vessels operating in fresh water show a low rate of corrosion. Vessels operating in salt water develop bulkhead failures in 6-8 years of clean trade. Data are based on the analysis of corrosion of 20 ships, some riveted, some welded, all operating in the Gulf-East coast trade and alternating between clean and dirty cargoes. Methods of corrosion control discussed are the mechanical approach (coatings, design, materials) and the electrochemical approach (oxygen elimination, moisture elimination, chemical inhibitors and impressed potential). Studies indicate that use of dehumidification, chemical treatment and galvanic protection will permit a 25-50% increase in the life expectancy of a tanker. The cost involved, \$10,000 per year on a 20-year basis, represents a saving of \$40,000 yearly per tanker. Hard points

of high corrosion must be corrected early in the ship's life, and salt water cleanings must be reduced to a minimum if the savings expected from anti-corrosive materials, corrosion inhibitors, etc. are to be achieved. 12 references. 8167

8.9.5, 3.7.3, 3.5.8, 6.4.2

Aspects of Welding Research in British Merchant Shipbuilding. I. Brittle Fracture in Mild Steel and Residual Stresses. II. Welding Aluminum Alloys and Full Scale Structural Tests on Welded and Riveted Ships. III. Tests on Structural Components, Fatigue Testing, Welding and Inspection and Comments on Structural Design. R. B. SHEPHEARD. *Shipbuilding and Shipping Record*; 83; Nos. 8, 9 & 10; 247-250; 280-282, 284; 309-312 (1954) Feb. 25, March 4, March 11; Abridged version in *Welding & Metal Fabrication*; 22; Nos. 1 & 2; 28-32, 69-76 (1954) January, February.

Lecture presented at the annual meeting of the American Welding Society, Cleveland, Ohio. Part II is a review of research on difficulties in welding aluminum; are characteristics; full-scale structural tests on welded and riveted ships. Part III deals mainly with mild and low-alloy steels.—BNF. 8275

8.9.5, 5.2.1, 6.4.2

Cathodic Protection (of Aluminum): Its Application to Ships and Establishments of the Royal Navy. J. T. CRENNELL. *Chemistry and Industry*, No. 8, 204-209 (1954).

Marine cathodic protection of aluminum, which is being used increasingly for small ships' hulls, is among the aspects discussed and illustrated. The potential giving protection to aluminum is in practice similar to that for steel and thus, with some exceptions, aluminum-alloy underwater fittings on steel hulls could be used without undue corrosion risk if the steel is cathodically protected.—MA. 8073

8.9.5, 6.4.2

The Performance of Aluminum in Ships. D. C. G. LEES. Paper before Soc. Chem. Ind., Glasgow Sec. & Corr. Group, Glasgow, March 5, 1954. *Chemistry & Industry*, No. 31, 949-955 (1954) July 31.

The choice of appropriate aluminum materials and development of correct fitting and protection practices are reviewed. Aluminum-magnesium alloys are used for plating and for rivets, while aluminum-silicon alloys are used for castings. Two examples of aluminum in marine service relate to boats with aluminum hulls since this use was earlier established than application to the superstructure. Extruded sections and cut ends remained sharp even in the bilges where maximum corrosion is expected. Examples of corrosion caused by junctions of aluminum alloys with other materials include corrugated aluminum awnings on a tanker, aluminum-magnesium sheathing over mahogany hull of a 105-foot launch in tropical service, application of unsuitable antifouling paint on a motor-boat hull and corrosion of aluminum lifeboats caused by chafing of paint which let an aluminum-steel couple come into play. Practices outlined cover treatment of aluminum-steel joints, contacts between aluminum and copper alloys, painting, anti-fouling compositions and protective anodes. Seven references.—INCO. 8125



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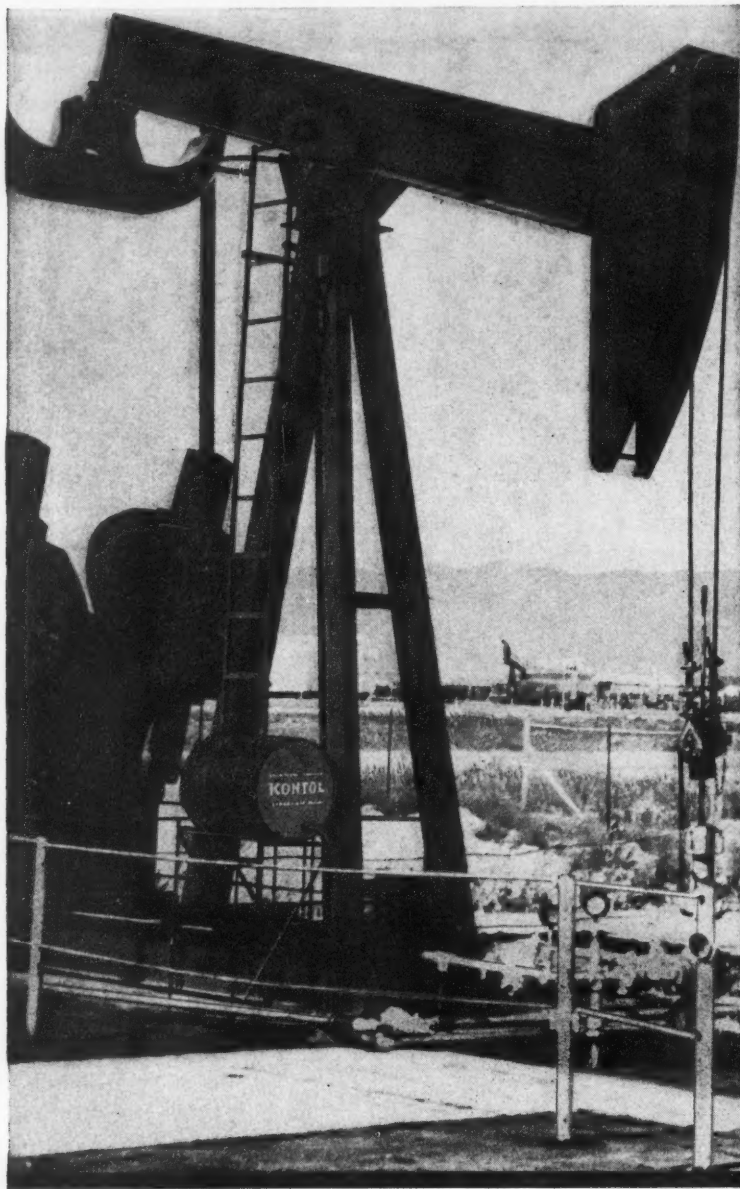


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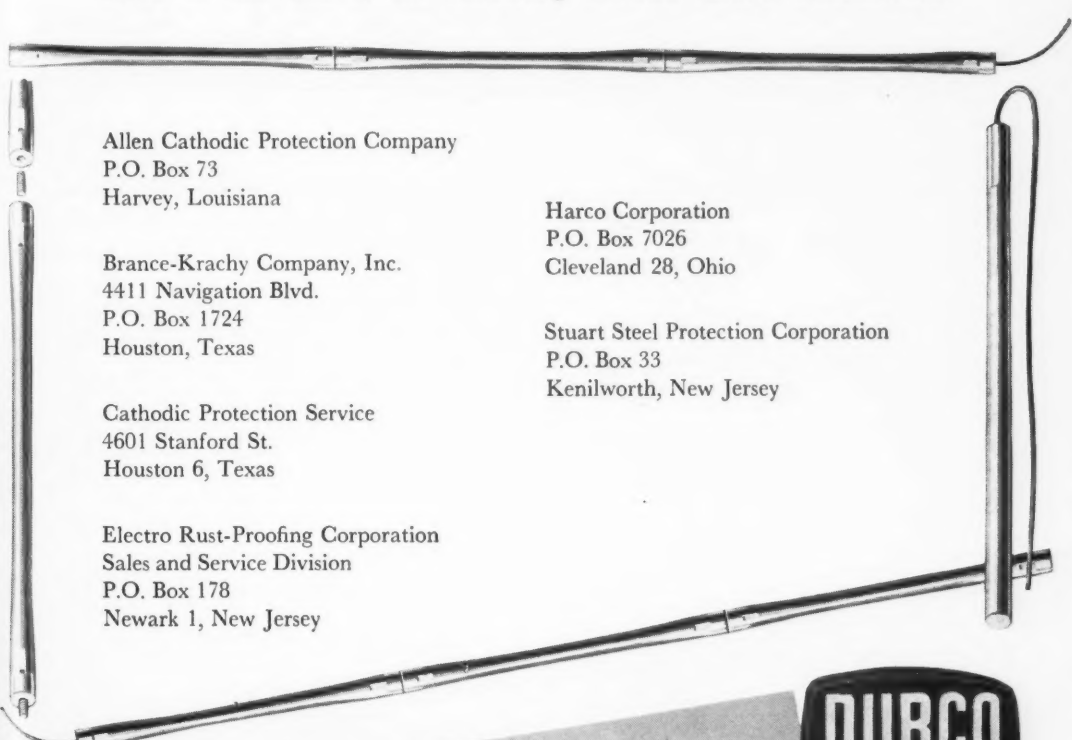
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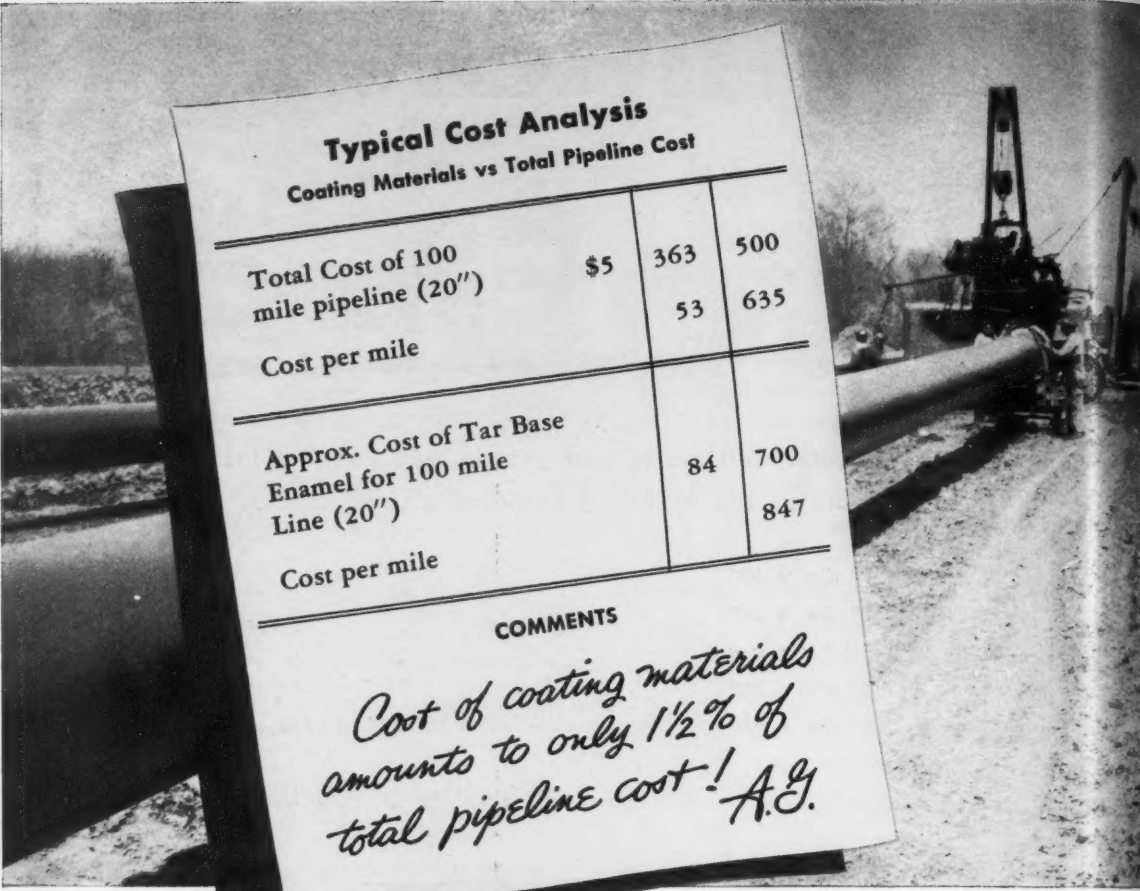
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Cost per mile			847

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